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Disrupting the Visualisation of Reality

How NCTech Wants to Enable Everyone to Capture Their Own Environment

INTERACTING WITH BIG GEOSPATIAL DATA

INCREASING INFORMATION IN BUILDING MODELS

SINGAPORE: TOWARDS A SMART NATION

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An Interactive 4D Reconstruction of a Historic Building in Virtual Reality

This May 2017 issue of *GIM International* shines the spotlight on capturing and visualising geospatial data. If companies such as NCTech are right – and this edition contains an interview with CTO and founder Neil Tocher – everyone will be able to capture their own environment in the near future. This issue focuses on ways to enhance the geospatial data experience and illustrates that we are on the brink of a major transformation.

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Virtual Future

During the Easter weekend I visited the Hermitage Amsterdam museum for the '1917. Romanovs and Revolution' exhibition – a wonderfully put-together display of personal belongings of the last tsar of the Russian empire and his family. The exhibition also provided a lot of information about the political and social history in the run-up to 1917, which led to the monarchy being overthrown and the Soviet Union being established. I had wanted to visit the exhibition for quite a long time, but had never got round to it – even though I already had the tickets at home. With a conference in Moscow coming up, I finally made an effort and it was more than worth it. What I especially thought was great was the combined use of sound and vision to bring the history to life. For instance, audio fragments narrated by famous Dutch writers told of Russian habits and a short film projected onto a wall created some sense of being in St. Petersburg at the turn of the century. It was simple yet relatively effective!

Also during the long Easter weekend, I saw a TV documentary about the making of the newly released Horizon Zero Dawn video game. Motion-capture sensors attached to an actor's body formed the basis for all possible movements when they were overlaid onto the characters in the game. More people play these games than watch the film industry's biggest box-office hits, yet the actors – filmed with cameras with no lenses – are not known to anybody, despite their alter egos in the games being world famous.

▲ *Durk Haarsma, publishing director*

In this issue of *GIM International* you will find an article on 'The Development of a Virtual Museum in Germany' by Simon Deggim, Felix Tschirschwitz and Thomas P. Kersten from the Photogrammetry & Laser Scanning Lab of HafenCity University Hamburg. The first sentence of their article (see page 27) informs us that a virtual museum (VM) has the potential to greatly improve the experience of a traditional museum visit, adding the possibility to provide information in a new, entertaining and convenient way. I'll leave it to you to read this interesting feature further for yourself, but it has set me thinking about the Romanov exhibition and what virtual reality could have done for the Hermitage Amsterdam. The Romanovs were amongst the first avid users of film and photography – there's an amazing amount of footage and images of the family and it would have been easy to build upon those using anonymous models and actors. That would have given me a more vivid experience of early-20th-century Saint Petersburg, it would have brought the tsar and his family 'back to life' – respectfully, of course – better than a simple sound and light show projected onto a wall. It also brings home to me the fact that – to have any hope of survival – all museums must embrace virtual reality as quickly as possible. I am certain that any museum which fails to embrace virtual reality today will have no tomorrow.

Overcoming Barriers to Regional SDI Development in the Americas

There is nothing else like INSPIRE in the Americas and most probably there never will be. Anyhow, at its own pace and under its own circumstances, the region is advancing in the process to build a sound spatial data infrastructure (SDI) for the Americas. If I must choose a starting point for this effort, it would be compounded by the establishment of SIRGAS – the unified reference system for South America – in 1993, the Interamerican Geodata Network established in 1996 and the UNRCC for the Americas held in 1997. So that means it has been more than 20 years already. That's a long time, isn't it? But, jumping to 2017, I can gladly share new developments in overcoming barriers encountered along this journey.

Recently, I attended the international seminar on 'Geospatial Information for Social, Environmental and Economic Development in the Americas' in Santiago, successfully organised by the Chilean government. It incorporated multidisciplinary presentations by leading experts and parallel workshops on GEOSS, disasters management and SDI national and regional initiatives – and, as an added bonus, the fourth meeting of UNGGIM: Americas and the first joint session between ECLAC's Statistical Commission and UNGGIM: A.

After this visit to Santiago I can conclude that SDI is moving on in the Americas. How? Well, UNGGIM: Americas is preparing itself to contribute to UNGGIM 2.0, including construction of the first geospatial and statistical data base for the region called MEGA; SIRGAS is expanding its already proven capacity-building skills across the region around reference systems; the Pan-American Institute of Geography and History (PAIGH), with support provided by the Development Bank of Latin America (CAF), is progressing towards a first seamless database of the Americas at scale 1:250,000, currently focusing on South America; at the same time, in coordination with the GeoSUR Programme, it has prepared a new version of the Latin American Metadata Profile (LAMP v2) and GeoSUR, in collaboration with the USGS and Spain's CNIG, will soon have a new version of its geoportal, adding new OGC-complaint services including a new and open metadata editor tool.

There are other relevant activities going on at the regional level, like PAIGH's proposal for a regional fundamental datasets policy, yet I believe this bouquet of activities is sufficient to indicate that SDI in the Americas is moving ahead with support from multiple actors, namely PAIGH, SIRGAS, UNGGIM: A, GeoSUR and now, too, AmeriGEOSS.

Santiago Borrero
GeoSUR Programme

3D Repo Cloud Platform Adds Integrated Virtual Reality Functionality

3D Repo has launched a new version of its cloud-based building information modelling (BIM) software that offers integrated virtual reality (VR) functionality using existing 3D models and project data. 3D Repo's multi-award-winning solution for those managing construction and civil engineering projects already uses the latest cloud technology for wider access, easier collaboration and open-source application development. With the addition of VR capability, users can now deploy VR simulations for applications such as training, safety and project consultation. The 3D Repo VR development differs from other VR simulations which utilise fixed content from standard game engines, meaning any edits require a complete reprocess of the entire simulation. With the 3D Repo solution, the web-enabled approach allows users to access all their projects remotely on the fly and without the need to create custom executables each time. 3D Repo also utilises existing site-specific 3D models and BIM data, so that custom scenarios can be created and uploaded as and when needed.

▸ **http://bit.ly/2om5SVi**

3D Repo Cloud Platform equipped with VR.

Hundreds of International Surveying and Mapping Experts to Gather in Wuhan

Held every two years, the ISPRS Geospatial Week (ISPRS GSW) is one of the world's largest and most comprehensive technical conferences focused on photogrammetry, remote sensing and geospatial information. The ISPRS Geospatial Week 2017 (GSW 2017) will be held in Wuhan, China, from 18-22 September, and a huge number of specialists and experts from all over the world will come together at this conference. The 10 topics covered by the ISPRS workshops include the 5th International Workshop on Web Mapping, Geoprocessing and Services, Laser Scanning, Indoor 3D 2017, the 10th International Symposium on Spatial Data Quality, the 2017 International Workshop on Image and Data Fusion, the 3rd International Conference on Spatial Data Mining and Geographical Knowledge Service, the 2017 ISPRS International Workshop on Advances in SAR: Constellation, Signal Processing and Applications, the ISPRS Workshop on Photogrammetric 3D Reconstruction for Geo-Applications 2017 and the 2017 ISPRS Workshop on Cryosphere and Hydrosphere for Global Change Studies.

▸ **http://bit.ly/2oKDA9G**

Wuhan, China.

Arithmetica Previews Point Cloud 3D Modelling Software

Arithmetica gave visitors at SPAR 3D 2017 an insight into how quick and easy it is to convert the vast point clouds generated by modern laser scanners into manageable 3D models. Dubbed 'simplified surfaces', the latest development by Arithmetica can deliver a tenfold decrease in the size of the resulting 3D vector models. Pointfuse is all about making laser scanned data more usable, according to Mark Senior, business development manager at Arithmetica. Pointfuse bridges the gap between the laser scanning hardware solutions, which are increasingly being developed to capture more data, faster and with better accuracy, and the huge array of specialist software solutions used within the heritage, architecture, engineering, construction, manufacturing, infrastructure and mapping sectors, for example, Senior said.

▸ **http://bit.ly/2ornyhF**

Google Streetview Pioneer Luc Vincent Joins Spotscale

3D technology company Spotscale has announced that Luc Vincent, one of the world's top thought leaders in the mapping space, is joining the company. He will assist in strategy and further development of relationships in the San Francisco Bay Area, USA. Luc Vincent spent 12 years at Google, establishing and overseeing many of Google's largest 3D mapping initiatives, including Google Street View and aerial 3D maps. At the end of 2016 he joined Spotscale as an angel investor and advisor. Currently, he is employed by Lyft in San Francisco as vice president of engineering. Vincent will bring a huge portion of domain expertise to further strengthen Spotscale's strategic position in the mapping space, according to Ludvig Emgård, founder & CEO.

▸ **http://bit.ly/2om9KWc**

Spotnik, the Spotscale mascot.

NCTech Unveils New 3D Virtual Reality Camera

NCTech, a UK-based developer of reality imaging systems, unveiled new reality capture products at the SPAR 3D Expo and Conference. The new developments are designed to put professional-grade reality capture into the hands of both technical and non-technical users, lowering the barriers to adoption of user-created virtual reality content. The LASiris VR is a 3D reality capture camera that combines vivid 120MP HDR imagery with a 100-metre-range Lidar scanner, seamlessly blending high-quality 360 imaging with colourised point cloud output for 3D visualisation. LASiris VR is relevant in sectors already using terrestrial laser scanning technology, such as surveying, engineering and construction, but is also intended for those looking for simple and economical access to reality capture, particularly for applications involving virtual reality, augmented reality and mixed reality. Easily controlled via an app from any smartphone or tablet, LASiris VR is suitable for any market where the capture of true 3D reality content is desirable. Examples include facilities management, where asset owners, facilities and project managers can easily collect their own realistic, as-built visualisations of a site, and stockpile measurement, where its simple operation means in-house staff can capture their own point cloud and calculate volume.

▸ **http://bit.ly/2pfzNIZ**

LASiris 3D reality capture camera.

Flying Fully Automated UAVs without a Pilot

Airobotics' Optimus UAV.

Airobotics has revealed that it is the first company worldwide to be granted authorisation to fly fully automated unmanned aerial vehicles (UAVs) without a pilot. The certification, that was presented by the Civil Aviation Authority of Israel (CAAI), solidifies Airobotics' status as a world leader in the field of automated UAVs and will enable even more innovative beyond visual line of sight (BVLOS) commercial UAV operations. This milestone proves that decisions and actions that were once taken by a human UAV pilot can now be taken by Airobotics' computer software and artificial intelligence. Essentially, an authorised pilot is now replaced by an authorised computer. The concept of a system operating on its own was designed and developed for the first time by Airobotics, solving some of the biggest problems for the drone market, such as high costs of labour, increased logistics around UAV operations, expensive and lengthy training of aircrew as well as enabling customers that are not UAV experts to perform highly complex UAV missions.

▸ **http://bit.ly/2pQW1Hn**

City of Coatesville Brownfield Redevelopment Project

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The Huge Potential of Virtual Reality for Geomatics

The 2017 edition of the *GIM International* Business Guide includes an article titled 'The Advancing Industry of Geoinformation'. I wrote the article, together with our contributing editor Martin Kodde, as a follow-up to a comprehensive survey we carried out among our readers. The article zooms in on the latest trends and developments in the surveying industry. In the article we state: "Two of the buzzwords that have been heard at geomatics trade shows across the globe in the past year are virtual reality (VR) and augmented reality (AR). In numerous keynotes and presentations, both technologies have been hailed as two powerful tools that may well make a revolutionary impact on the survey industry. But although the spotlight has been shining brightly on VR and AR, today's geomatics professionals have relatively subdued expectations of working in a virtual or augmented world. The question is: are geomatics professionals simply more conservative than their peers in other industries, or are VR and AR – apart from being nice gimmicks – not actually beneficial for geomatics applications?" Although just a couple of months have passed since our readers' survey and in spite of the seemingly slow adoption of VR in the geospatial sector, we feel that this topic deserves extra attention. Therefore, this issue of *GIM International* is focused on the visualisation of 3D data, with virtual reality as a key ingredient. As the engineering and construction(E&C) industry is a relevant vertical in the geomatics world, we believe it is necessary to keep you – our readers – informed about the wide-ranging technological possibilities opening up. After all, 3D modelling is a key topic in our field and both VR and AR are already being shown to add value.

In the construction industry, 3D models are used to facilitate project management, detect potential problems before the construction work starts and ensure a smooth workflow. Virtual reality enables users to experience the environment from a human perspective and hence gain a better sense of space.

Now, virtual reality is on the brink of moving beyond just architecture, engineering and construction applications and evolving from a hype into a useful – if not essential – tool for many geospatial professionals. How about urban planning, for example? VR is ideal for planning purposes and is set to revolutionise the profession. City planners can use 3D mapping and VR to visualise new districts.

A good example is Dutch company Tygron, which has developed a platform called the Tygron Engine. It supports decision-making by visualising geodata, modelling it and facilitating interaction in a virtual 3D environment. Based on gaming technology yet strictly serious, this virtual 3D environment enables several 'players' – in this case representatives of government authorities, project developers, interest groups, citizens and other stakeholders – to interact simultaneously. This approach fosters consensus and understanding and streamlines the communication process to advance projects more quickly. The enormous potential of 'serious gaming' in a virtual 3D environment has already been recognised by various governments and other authorities across the globe.

So how are the key players in the geomatics industry exploring the potential of VR? The most eye-catching example comes from US-based Trimble, which has teamed up with Microsoft and the UK's University of Cambridge with the aim of bringing wearable holographic technology (the Microsoft HoloLens) into the E&C field to provide construction-sector stakeholders with the information they need. Virtual reality can support informed decision-making and can improve the lifecycle management of physical infrastructure assets.

For other applications of virtual reality and to gain an insight into the potential future of virtual reality, read the various articles and also the interview with Neil Tocher, CTO of NCTech, elsewhere in this issue of *GIM International*. ◀

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▲ *Wim van Wegen.*

Save the Date: YellowScan International User Conference


YellowScan Mapper.

This year's YellowScan User Conference will take place from 29-30 June in Montpellier, southern France. The event will include demos and conferences about the company's lightweight integrated Lidar systems and their technical specifications, the unmanned aerial vehicles (UAVs) used for Lidar, and the data processing and analysis. Other key features will include industry case studies and technical workshops, what's new and what's coming at YellowScan, and of course making connections and sharing information about efficient workflows. After hours, the event provides plenty of opportunities for networking during various social activities such as wine tasting, a concert and more.

▸ **To register or for more information: contact@yellowscan.fr**

Remote GeoSystems Launches New Google Earth Video Extension

Remote GeoSystems has released the new LineVision Google Earth Extension. This commercial software solution is suitable for UAV, airborne and terrestrial mobile inspection and survey projects requiring georeferenced video playback, analysis, collaboration and reporting using Google Earth and other GIS applications. Unlike its stand-alone predecessor, the new LineVision Google Earth is a true application extension and gives users the full functionality of native Google Earth, including Pro edition. Now anyone with a GPS-enabled video camera, drone or geospatial DVR that can geotag video in the proper format can immediately load their videos and photos to Google Earth along with compatible KML and other traditional geospatial data.

▸ **http://bit.ly/2ormhHo**

INTERVIEW WITH NEIL TOCHER, CTO, NCTECH

Disrupting the **Visualisation of Reality**

The way we capture the reality is changing rapidly. One of the pioneers leading this change is NCTech, a Scotland-based company specialised in 360-degree reality imaging systems. The company works with renowned names such as Google and Intel, and also with geospatial powerhouses like Leica, Topcon and Trimble. *GIM International* talked with co-founder and CTO Neil Tocher about the strong ambition to enable everyone to capture reality and to democratise and disrupt the industry by making virtual reality the new standard for visualising our environment. A range of new applications is looming for the geospatial sector. Are we on the brink of a major transformation?

Let's start by taking a look at the geospatial industry. Traditional survey techniques are still widely used, but there are also new methods for mapping and surveying. Where do we currently stand?

You're absolutely right. It's not an industry that you want to change overnight; the traditional methods do have their value. The industry is all about accuracy, so we are trying to look at the workflow, how can we make things easier and more efficient. The industry of tomorrow will be one with an 'image first, scan second' approach, and we hope to push the market towards this. This means imaging will be much easier and faster to collect on site than Lidar, which is a very reliable method of measuring. Photogrammetry has been around a very long time, but you can get varying results and there's a lot of known issues with it. We're combining both: photogrammetry is the fast solution but we're also backing that up with some basic Lidar to help the transition to faster and easier visualisation of reality. It's all about the delivery as well – what you're doing with that data. If it's for visualisation, high-accuracy tools aren't required; it can be done much faster with new tools that are designed for that process, which is where we're heavily focusing on.

How is your company contributing to the industry's transformation?

The transformation is about the workflow. By combining and introducing these new hardware solutions, we're trying to gradually step over to a more photography-based technique rather than Lidar, hand in hand with our visualisation tools and backed up with the improvements that are happening in the cloud. People talk a lot about the cloud, but so far it's mainly been somewhere to host your data for sharing. We're really enhancing the power of the cloud with Intel and with Google, and we're gearing up the processing power that we have to handle big datasets and produce much more accurate in-depth processes with the data that we're collecting. So the accuracy is there and we can handle it; these new hardware tools plus new tools in the cloud deliver a whole new way of processing. We're trying to move away from having all the data come back to the office to be processed on a powerful workstation, which can be very time-consuming. We're splitting that processing up over multiple hardware devices in the field and those individual devices are pushing to the cloud – a more collaborative network of hardware, or the Internet of Things (IoT) as they call it these days. We're bringing in other technologies as well, such as drones which we see as being a big part of what we do moving forward. We hope to bring these technologies into these industries seamlessly and also fully autonomously.

You mentioned unmanned aerial vehicles (UAVs or 'drones') – what role do they play in your company?

Drones are a little like virtual reality (VR) – a buzzword that everyone is talking about but not really harnessing yet. Drones are being flown around above survey sites and the data is being uploaded to show you a bird's-eye view, and possibly using photogrammetry they sometimes create a 3D model – that's great. But we're working on new sensor technology with Intel that can be UAV-mounted, as well vehicle-mounted, as well as tripod-mounted. So we'll have a whole new range of sensors to add to our armoury for pushing to the cloud, and drones are just another way of automating that collection service. One scenario could be on a construction site: if you want a regular daily or weekly scan on site to see how things are developing, drones could be setting off in the evenings and scanning when the site is quiet. So drones are just one more asset in the overall capture reality hardware.

You started in 2010 with the launch of your iSTAR camera. How has your company matured since then?

It's growing – fairly steadily until recently. The iSTAR camera was originally developed for the police and for the military. When we entered into the engineering & construction (E&C) market the camera itself was capable to use that hardware but the workflow wasn't, so we spent some time developing the software tools and integrations to make the camera fully integrated with the workflow and the current software. That lifted the barrier to market for the camera and it became very successful in E&C for colourising existing

scan data. We've been working in other industries such as professional photography, we're working with Google, and we're about to embark on some large projects which include new hardware developments, the fruits of several of which we've announced recently: with the LASiris VR, the iris Pro and the iris VR. Another new product is our mobile mapping camera, a high-resolution camera that is vehicle-mounted for taking images as you drive. With all of these products we're now doing 2D imaging and 3D depth imaging, but behind them all is our new cloud platform. Now that we have the complete package from end to end – from capture all the way through to delivery – this year it's all about realising all those products and about gearing up for high volume, especially since we're entering the consumer market with the iris VR, for which we're working closely with Intel and Google. That gives us access to a broad array of customers, from consumers all the way up to construction. We're very excited about pushing VR and the capabilities of these products and getting them into the hands of consumers. This will disrupt and democratise VR, it's going to open up and empower the whole VR industry to be a lot more creative – which will be very beneficial for industries such as construction also.

Virtual reality is hotly tipped as one of the potential disruptors in the industry. What are your expectations, and what do you regard as relevant application fields?

We believe it's important to educate the industry. If it's left to the big names out there it will be pushed down a certain route for a commercial reason, whatever that may be. We are a smaller company but we share the same vision as Google and Intel. We really want to get the best possible product we can into the consumer market, to empower people to capture their own reality that's around them. It's only when you can get reality capture at that scale that VR will really become a success. It's kind of like YouTube: when everyone uploads their own content, it becomes unstoppable as a huge, reliable tool. We feel that if only the big names in the industry are doing it then it has a chance of failure – it will be exciting for the first year or so that people use it, but that content then becomes stagnant or less relevant to the user base. So we want to make sure that we let create their own content and hence minimise the chance of failure. This will benefit all the developers and all the hardware companies, whether for visualisation, for displaying VR, for all the associated accessories and so on – everyone is going to win from that. Behind this movement you need a very simple solution; as soon as you move to consumer it needs to be a one-button process to the cloud. NCTech is about all of this: straight-out-of-the-box tools that are doing an amazing job, with the whole process carried out automatically. If you want to use the data to do something very creative with it, you can. We don't lock people in to proprietary systems, that would only be prohibitive to further developing new things.

Hybrid technologies are gaining ground, such as the combined collection and processing of imaging and Lidar data. Are you also involved in these developments?

Yes, all of our new products that are collecting depth are also collecting imaging at the same time. Whether it's a static product on a tripod or a mobile product on a UAV or on a vehicle, they are generally collecting the RGB colour information as well as the depth information. This is an idea that we're investing a lot of time and a lot of development work in. Whenever NCTech is mentioned, I expect most people think we are a hardware company. We're actually a software company more so than a hardware one. The hardware is really developed to enable the software to deliver the output. When you buy a camera you don't buy it for its look and feel, you buy a camera to take pictures; the image is the product that you're buying into. It's the same with our products – they are there for a reason, namely to capture data, and that data needs to be processed. So we put a huge investment into the processing of that data and making it available to everyone through an automatic pipeline. From the point of capture up to the cloud and in delivery, whether that's to VR or simply a third-party application, we want to make sure that our software in the cloud handles colour image, scan data and everything else in between – videos and so on. Whereas the hardware development basically stops once you start shipping, the software development is a never-ending story.

Processing and visualisation of captured data are becoming more and more important. Which trends do you expect to succeed?

The visualisation of data really depends on the size of your data. Zooming in on the devices of today, everything is about the Internet of Things: multiple types of device communicating over the internet. In everything we do, it's important to us that all of our products and services are available through the internet, to multiple platforms and devices – whether phones or computers – which means through the cloud and through WebGL for the user interface. No matter how complex or how big that dataset is, we've been working on ways of pulling that data down to satisfy and to maximise the potential of the device you're looking at that data on. If you're using a low-resolution screen, it will only provide you that resolution of data because that's all you can see. But if you're looking at it on your desktop computer, you will get a much higher-resolution download of that content. For us it's all about the cloud and IoT – we feel that's the future for data sharing. It's not about a desktop computer and people sending large files to each other, it's about streaming data almost on the fly. It's about the collaboration of the devices out there doing the collection, the cloud doing the processing and people dialling in and pulling out what they need at that point in time. That's the most efficient way forward for everyone.

You are pioneering in VR point clouds. Can you explain for us what VR point clouds are and why they are so relevant?

Point clouds in the E&C market are generally created by laser scanners and can be very large, dense files to download. If the files don't have colour information they can be very hard to make sense of for a layman, and therefore you need an experienced user to understand how to manipulate these point clouds and to understand what you're looking at. Adding colour to point clouds gives them a whole new dimension because the human brain finds it easier to understand colour. So colour helps you to make sense of a point cloud, but the file size is still huge. As an interface it can look like a poor photograph of the real world from a different view point, and as you go closer the points become sparse and disappear. So point clouds are great as a tool for measuring, but VR is about creating and taking a real-world place and virtualising it. Our view on point clouds is: we understand that high-end laser scanners can identify a wrinkle in a carpet, but do you need that level of accuracy for the visualisation of a space? The answer is no. You just need to know that the space has a carpet, and you need to know its size and dimensions, but you don't need to know its texture or that there's a wrinkle. Therefore you don't need a high-density point cloud. Another issue is, whether you have a VR headset on or not, when you're viewing a point cloud it still doesn't look like a real image. It only looks real in an extremely high-resolution dense point cloud from a position that has no occlusion. As you move away from that point of origin and the occlusion kicks in and you see issues, it ruins your virtual reality experience. What you really want with VR is the ability to move around in the three-dimensional space freely, but also to take the point cloud information which is there behind the scenes. You want to use the colour photographic information and map that to simple geometry that's been generated from the point clouds. The point cloud is there, but the user doesn't see it; the geometry is also there, but the user doesn't see it. What the user sees is a combination of both where the colour information has been mapped onto that simple geometry, giving a very lightweight model that can be moved around very rapidly. If the VR is to be viewed on a phone or a PC over an internet connection, it needs to be fast and lightweight. With VR, it's also key that when the user turns their head the model can be moved at a rate that doesn't given any nausea or have any slow latency. With large point clouds that's a big problem: the download time of all the information will create a lag and then the user will become disorientated or feel ill. Therefore it's important that with VR, with point clouds, we streamline that for the user experience rather than for the accuracy that point clouds give you for measurements and other details. It's a trade-off: we have to simplify to improve the experience, but if you want to introduce measurements and other features into that VR experience we can still pull the high-resolution point cloud for the area of interest into that environment from behind the scenes so you can perform advanced measurements.

You've migrated your 3D visualising software ColourCloud to Google Cloud Platform, and Intel is also part of this alliance. Can you tell us a bit more about this?

Sure! As I already touched on, NCTech has a very strong and clear vision of future IoT technologies for reality capture including VR and augmented reality (AR). Google and Intel share that same vision and together we're pushing to make the best products and experiences we can for everyone, from E&C to many other verticals. The whole point of our 'colour cloud in the cloud', as it were, is to enable whatever hardware product we bring to the market and to give those suites of tools we've developed to users without them having to understand exactly what is happening to the data they're collecting, wherever they are. If the product needs to use our ColourCloud technology, then that process will just happen as a matter of course due to the way the data is pushed to our servers; the processing takes place without the user being aware of it. At the end of the day they get the amazing result they wanted. Using Google and Intel gives us the best-quality servers, the most powerful processing available, and maximum disruption and reach to the industry to ensure that these new products are a long-term success rather than just an overnight one. They can then continue to develop in conjunction with these large platforms. Our relationship with Intel is very strong: it's not just at a software level or with their servers, it's very much also on a hardware level. We're utilising new chips, new technologies, new drivers, a new workflow, all the way up to the cloud and delivery. It's a very good alliance; those guys are very excited to be working with us, as we are with them.

Which other major changes or disruptions do you foresee in the geomatics industry?

[Laughs] This is quite an interesting question, but there's a limit to what I can disclose! Let me say this: we've been working on some new technology which we are very excited about, for the last two years. For example, we have recently released the LASiris VR, which was actually developed in 2015 but we sat on that product because the market wasn't ready for it. We very much do foresee how the market should go, but we don't just build it and then try to sell it because we think we should. We only do it when we know it's going to succeed or when the market is ready for it. The market is now ready for the LASiris VR, there's enough support out there for VR and the LASiris is perfect for high-end VR, hence it has been well received now. There are new technologies coming in the automotive industry, and also with drones as I've mentioned. We're really excited about getting those new core technologies that we've developed for the high-end sector and E&C and precision down to the consumer level, because once it's at consumer level it is then adopted everywhere. It becomes mainstream and then you can start to connect new verticals to each other through that new technology. What I'm personally looking forward to are things such as online shopping, which is an area we've had a vision on for many years already. Using reality capture hardware you can capture your own property/living space, using iris VR to capture and scan objects, those objects are on our cloud platform and you can bring them into your own virtual reality world. With AR and VR together, it can give you a truly immersive shopping experience in your own home with accurate sizes, dimensions and so on. It adds a totally different dimension to the simple process of shopping. There's some exciting news coming with regards to that, and we're really looking forward to rolling out that type of vision. It's good to realise that without adequate reality capture hardware, none of this will be possible. We need to be able to make that hardware disruptive and low-cost. Without that, it's never going to be something that everyone is going to adopt and use day to day. That's the big challenge we're pushing to solve, and I think we're on a good road to achieving that within the next couple of years. ◂

NEIL TOCHER

Neil Tocher is a John Logie Baird award winner and has been a serial entrepreneur for over 22 years, working with large multinationals including Intel, Google, Apple, Adobe and Microsoft. Tocher has helped pioneers across many sectors from government and oil & gas to movie studios and media, developing leading-edge 360-degree 3D VR technology in both software and hardware. Tocher's extensive commercial, technical, programming and product design experience combined with his passion for innovation drives NCTech forward as a global market leader in the field of reality imaging systems.

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METHODS FOR VIRTUAL EXPLORATION AND VISUAL ANALYSIS

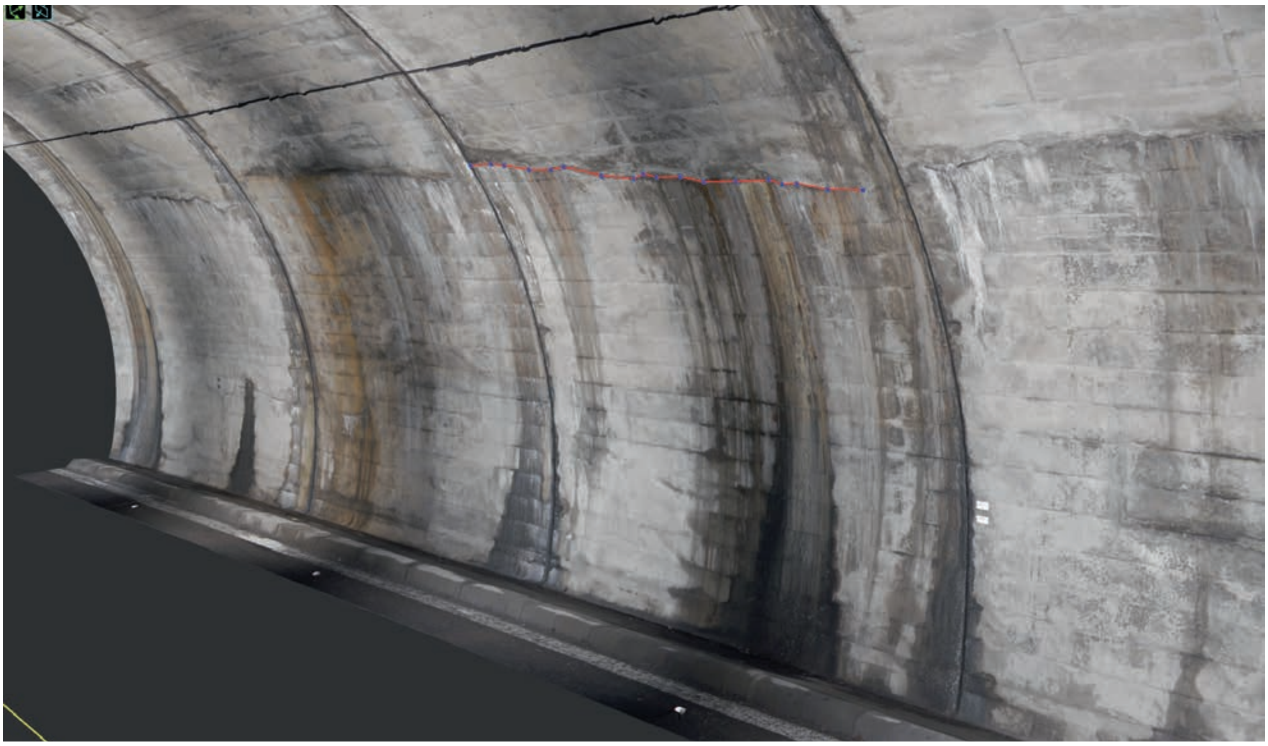
Interacting with **Big Geospatial Data**

Advances in capturing techniques such as laser scanning and photogrammetry have significantly increased the volume of geospatial datasets. Big geodata has become an important asset for analysis and decision-making, but also poses a challenge for state-of-the-art visualisation techniques. This article presents research results addressing this problem for the infrastructure and planetary science application domains. The methods discussed here enable users to fluently explore and efficiently analyse the growing wealth of geospatial data.

The data volume of 3D reconstructions is steadily growing for two reasons. Firstly, there is a demand to increase the accuracy of data acquisition, now reaching even sub-millimetre scales in some use cases. Secondly, the geographical area covered by a single 3D scene is becoming larger and larger. Many application domains expect both of these requirements to be fulfilled. Terabytes are quite typical today. While this is not a big problem for the current capturing devices, it easily exceeds memory and processing limits of interactive visualisation tools. Users are often forced to either reduce the datasets or to subdivide them and study single parts separately. A reliable monitoring or exploration tool, however, should allow for high-accuracy 3D models that cover large regions or structures. Users want to experience 3D reconstructions in a broad range of scales by seamlessly zooming in and out. This is important not only to observe small features in their much larger geospatial context, but also to efficiently compare different regions of interest and establish spatial relations.

AARDVARK

Research into this visualisation problem resulted in the high-performance visualisation



▲ *Figure 1, Visualisation of a tunnel wall with the red line showing a critical crack.*

Figure 2, GEARViewer visualisation of a planned street network in Linz, Austria.

framework called Aardvark. It is based on specific requirements from the industry and has been further developed in close cooperation with academic and commercial partners. The geometry of reconstructed objects is represented by a well-balanced hierarchical data structure, called Ordered Point Clouds (OPCs). It consists of several levels of detail (LODs), each of which corresponds to a certain geometric accuracy. Therefore, OPCs are multi-resolution scene descriptions. This is one major advantage in comparison to unordered point clouds. Another advantage is the ordering, which allows efficient generation of meshes on the fly. A smart metric is applied to choose the appropriate LOD during interactive visualisation. This metric depends on the distance of the viewpoint, the viewing angle and the area that a surface patch covers on the screen. LODs are smoothly switched depending on the user's navigation through the scene. Large objects such as terrains are subdivided into several patches, for which LODs are chosen independently. Thus, distant areas have a lower accuracy than regions close by. This technique enables an interactive virtual exploration of very large geospatial scenes from points clouds with billions of elements.

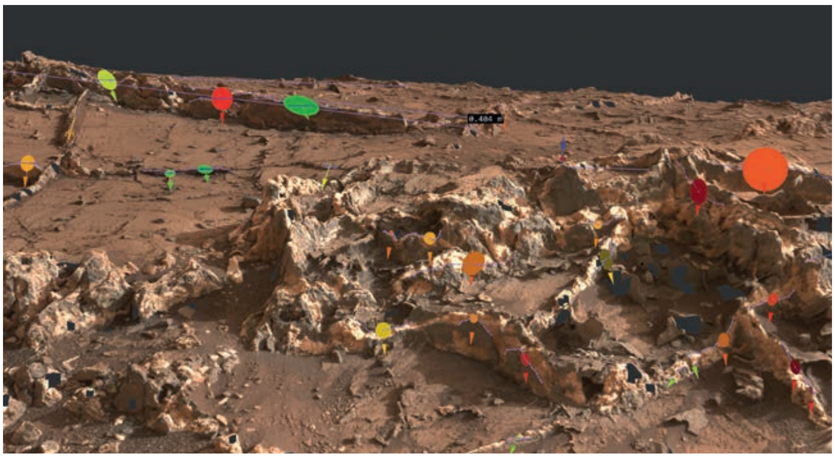


Figure 3, Geological analysis of gypsum deposits on Mars using PRo3D.

VISUAL ANALYSIS RESEARCH

There is a growing demand for data-driven navigation and selection in most application domains. An effective visualisation and analysis system should therefore guide the user to locations where the data has certain properties (and highlight them). These properties are often the result of simulations, for example a visibility analysis or the detection of surface anomalies such as cracks. To this end, spatial and non-spatial visualisation can be combined by linked views in Aardvark. Users then can interactively study non-spatial data using visual analytics tools. Any data entities selected are immediately highlighted in the 3D viewer and the user is guided to the relevant locations on demand.

Research has also been done on methods to visualise non-spatial data directly in 3D space. This establishes the geospatial context of sensor measurements and simulation results. Such techniques include false colour texturing of 3D surfaces, embedding appropriately aligned 2D diagrams or position-dedicated 3D objects which display data properties. They can also be animated to show the temporal dynamic of some data. Users also want to measure and annotate 3D reconstructions to perform manual analysis. Examples are distances, inclinations, orientations or simply obtaining the georeferenced coordinate of a surface point. Most CAD applications provide tools for that. But for very large scenes, highly optimised methods are needed to efficiently determine the location clicked on by a user. These methods build up bounding volume hierarchies that subdivide 3D space according to the scene content and thus significantly reduce search time. This data structure ignores LODs and only subdivides the geometric representation with the highest resolution. Since only the highest resolution is relevant for reliable measurements, LODs are an optimisation for rendering while bounding volume hierarchies are one for interaction. These research results have been successfully applied in the three use cases described below.

MONITORING OF TUNNEL CONSTRUCTIONS

Civil engineers rely on high-resolution 3D reconstructions of tunnel walls to detect flaws such as deformations and cracks. This is a typical application for which a high accuracy is demanded while simultaneously covering a large area. Cracks are rather small, but tunnels can be very long. Aardvark is able to show thousands of surface anomalies at sub-millimetre scale over several kilometres of a tunnel reconstruction. Small features in the distance are thereby enhanced or accumulated so that they can be better perceived. The visualisation system guides users to regions of interest by data-driven navigation. An example are cracks in the tunnel wall which exceed critical dimensions and where repairs are needed (see Figure 1). To support the detection of changes over time, data from different dates can be visually compared. Consideration of such temporal aspects helps in planning the maintenance cycle of tunnels.

LARGE-SCALE TRAFFIC PLANNING

For most large infrastructure projects, it is mandatory to assess their impact on the urban and rural environment before they get underway. Many shareholders want to involve the public or are even legally obliged to do so. For interactive exploration, a virtual reality application is needed that supports very complex scenes. They should be realistically rendered for sufficient credibility. Applied research on this topic (in close cooperation with industry partners) resulted in GEARViewer, a geospatial rendering framework based on Aardvark. It supports huge geospatial scenes consisting of large-scale terrain models, buildings, roads, tramways, railways, tunnels, vegetation and a skylight model. Everything is georeferenced. It can import GIS data and turn it into 3D objects. In the future, it will also support building information modelling (BIM) standards. GEARViewer considers illumination conditions for both day (skylight) and night (street lamps). Furthermore, it simulates traffic in a simplified way including cars, trams, trains and pedestrians. In summary, GEARViewer enables a realistic and vivid experience of planned infrastructure projects and allows assessment of their effects on the real environment. It has been used for many planned projects in Austria and Germany, such as A5 Nordautobahn, A26 in Linz and a highway project in Cologne.

VIRTUAL EXPLORATION OF MARS

Inthis extraterrestrial use case, planetary scientists – especially geologists – require 3D reconstructions of the surface of Mars as an important aspect of mission planning. Studying images from rovers alone is insufficient, tedious and error-prone. In the field, geologists investigate structures from various perspectives and distances by walking around before taking measurements. This is necessary to understand their characteristics and formation. A special 3D viewer based on Aardvark, called PRo3D, has been developed to enable planetary scientists to virtually explore reconstructions of the Martian surface. It is based on high-resolution geometry created from rover imagery (e.g. NASA's Curiosity rover) by Joanneum Research. Due to the multi-resolution approach, these models can be embedded into lower-resolution terrains created from orbiter imagery, establishing the larger geographic context. PRo3D allows geological analysis much like real field analysis. Users can navigate fluently through the reconstruction and get the full spatial experience. The viewer also provides various interactive tools for performing measurements and making annotations directly in 3D space. Figure 3 shows the result of an extensive geologic interpretation session for a region called Garden City within the Gale crater on Mars. The dimensions of various structures are obtained by distance measurements. Polylines are used to delineate stratigraphic boundaries. A special tool called Dip-and-Strike reveals the inclination of layers and is used to derive ancient flow directions. PRo3D has been used for many such interpretations by scientists from NASA and ESA.

CONCLUSIONS

Research into geospatial visualisation resulted in the Aardvark framework, which has evolved into a mature basis for the development of interactive solutions enabling virtual exploration and visual analysis of huge datasets. Small geometric details can be investigated within large geographic scenes that also integrate non-spatial data. In the future BIM compliance will be addressed, as this has become very important in the infrastructure domain. Furthermore, research is ongoing into the combined visualisation of spatial and non-spatial data to provide a comprehensive and holistic experience of complex scenes. ◂

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- C. Traxler, G. Hesina, R. Barnes, S. Gupta, G. Paar (2016) The PRoViDE framework for the quantitative geologic analysis of reconstructed Martian terrain and outcrops, Proceedings of EGU 2016.

Aardvark website: www.vrvis.at/research/projects/aardvark/

ACKNOWLEDGEMENTS

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UNDERPINNED BY A 3D NATIONAL MAP

Singapore: Towards a **Smart Nation**

Since the inception of its Smart Nation programme in 2014, Singapore has emerged as a world leader in smart city initiatives. One of the centrepieces of Singapore's strategy has been the development of a highly accurate 3D digital map of the country to support key functions such as urban planning, flood control and civil aviation. The creation of this national 3D map has involved the use, adoption and development of world-leading surveying, mapping and GIS technologies. This article explains the various challenges in creating and maintaining the required data, and how it will be used to its fullest potential.

The city-state of Singapore covers an area of just 718km². With the current population of 5.5 million expected to increase by 10% to 6 million in 2020, Singapore's government has proactively launched its Smart Nation agenda to ensure that the quality of life for residents is not only improved, but also maintained in the future. While other countries may not face the same limitations as Singapore in terms of land availability – for example, the USA is over 13,000 times larger than Singapore by area – other cities around the world are presented with similar challenges in terms of managing populations of increasing size and density.

In Singapore, a technology-driven approach has been adopted to tackle these issues, as geospatial technologies help to maximise the use of land resources in a region with only limited space. Therefore, as part of the Smart Nation programme, the Singapore Land Authority (SLA) has been tasked with leading the development of a high-resolution 3D national topographic map.

A CHALLENGING ENVIRONMENT

The first phase for creation of the 3D national map involved undertaking an airborne Lidar and imagery survey. With its equatorial climate, volatile weather, low cloud conditions, military restrictions on civil aviation and close proximity to neighbouring Malaysia and Indonesia, Singapore presents a very challenging environment for aerial surveying. In addition, one of the world's busiest airports, Changi, further complicates aerial survey access in and around Singapore. AAM Group, which was awarded the competitive contract in 2014 to capture and deliver the first phase of the national 3D map project, utilised a two-aircraft approach to make the most of the limited availability of survey windows. One aircraft was focused

▲ *Figure 1, A view of Singapore's dense urban landscape.*

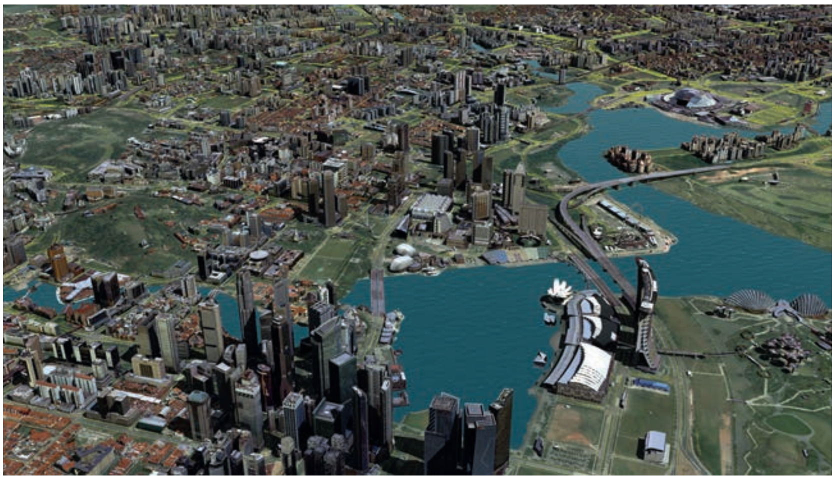


Figure 2, 3D model of Singapore's famous Marina Bay and downtown areas, produced in phase 1 of the SLA project.

Figure 3, Mobile mapping system used to acquire point cloud and imagery for Singapore's 5,500km road network.

on imagery capture while the other was dedicated to Lidar, which could also be conducted at night-time.

SECURITY RESTRICTIONS

Due to strict data security requirements, all processing must be undertaken in secure government facilities within Singapore. This required a dedicated one-off computer set-up coupled with security clearances for key personnel. Once established during the first phase, AAM teams began the task of generating 3D models for the approximately 160,000 buildings that make up Singapore's urban landscape (Figures 1 and 2). Since completion in January 2016, this part of the project has won a number of awards in the geospatial industry, largely due to its unprecedented achievement of mapping an entire country using established open standards – such as CityGML – to ensure the model is interoperable and future-proof.

STREET-LEVEL SURVEYS

Singapore's attractive tree-lined streets and dense built environment restrict the features that are visible from the air. To overcome this, SLA issued a tender to capture mobile mapping data of the whole of Singapore's 5,500km public road network. The mobile mapping survey included simultaneous mobile laser scanning (at a capture rate of over one million points per second) integrated with high-resolution spherical imagery (Figure 3 and Figure 4). The data was then further processed to extract details of both natural and man-made features at street level. AAM Group was once again awarded the tender to undertake this work, which involved being reacquainted with some of the survey challenges from phase one, along with being introduced to a few new ones.

SMOKE HAZE

Once again, weather conditions created significant challenges for the ten-month long campaign to map Singapore's streetscape. Acquisition began in September 2015 and was completed in June 2016. In addition to monsoonal rain periods, Singapore also encountered a severe spell of smoke haze in October 2016. This condition occurs periodically due to forest fires in neighbouring countries resulting from the common practice of open burning to clear land for agricultural use. The intensity of the smoke haze varies from year to year, depending on various conditions including wind direction and rainfall. At peak levels, visibility was severely reduced and image quality compromised, affecting the ability to utilise the imagery in downstream tasks such as modelling and feature identification.

FLEXIBILITY

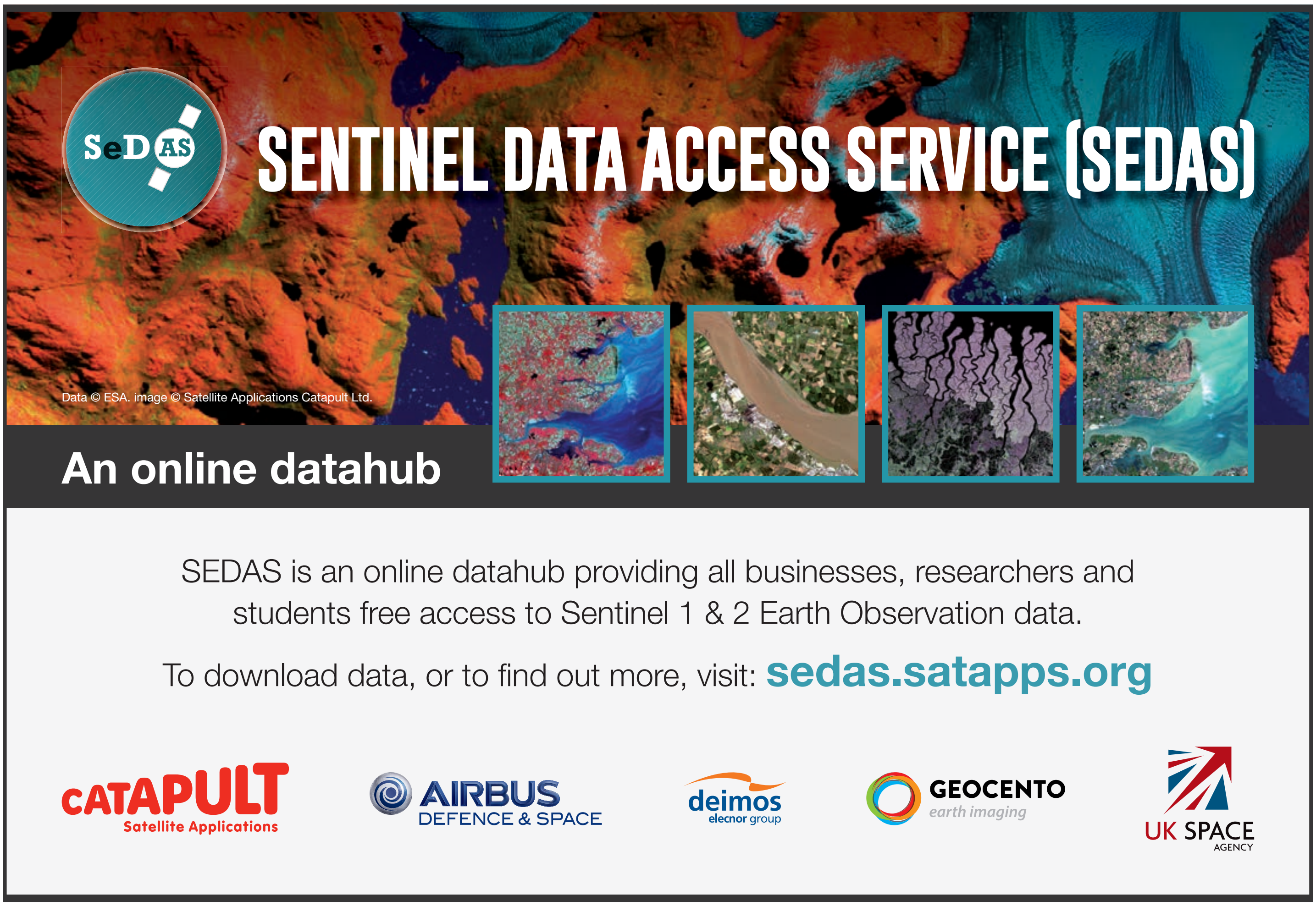
As with any vehicle-based survey in a built-up urban environment, there is also traffic to contend with. Adaptive planning and scheduling was required to survey areas at the most suitable times. A seven-day roster was implemented, with weekends being used predominantly for the central business district (CBD) and industrial areas and leaving largely residential areas for weekday operations. Mobile mapping surveys in urban networks also add new degrees of complexity compared with open highway environments. Significant additional capture and processing techniques needed to be put in place to ensure complete coverage, especially around complex intersections and flyover sections. A combination of both fundamental and leading-edge land survey techniques were also employed to ensure a suitable level of accuracy, especially in Singapore's tunnels and seemingly endless urban canyon environments.

DETAILED INTEGRATION

With the initial data acquisition now completed, work is currently underway to produce 3D models from the data. Phase two will see models created for the transportation network and city furniture, including objects such as bus stops, street lights, traffic lights and overhead bridges. These models are being integrated with the terrain and building models produced from the first phase of the national 3D map project. One of the key components of this integration is adoption of the CityGML standard, which is an open data model and XML-based format for the storage and exchange of virtual 3D city models, developed by the Open Geospatial Consortium. A CityGML schema has been developed for models from both projects, allowing the data to be seamlessly combined, analysed and shared across various departments. Guy Perry, former executive director of Asia-Pacific at AECOM, describes the detail and resolution of the 3D national map as being "at a level of integration and scale that no one else has done yet".

VIRTUAL SINGAPORE

One project that is showcasing the scale and detail of the 3D national map is Virtual Singapore, which is a collaborative 3D planning tool currently being developed by the National Research Foundation (NRF) in collaboration with Dassault Systemes (Figure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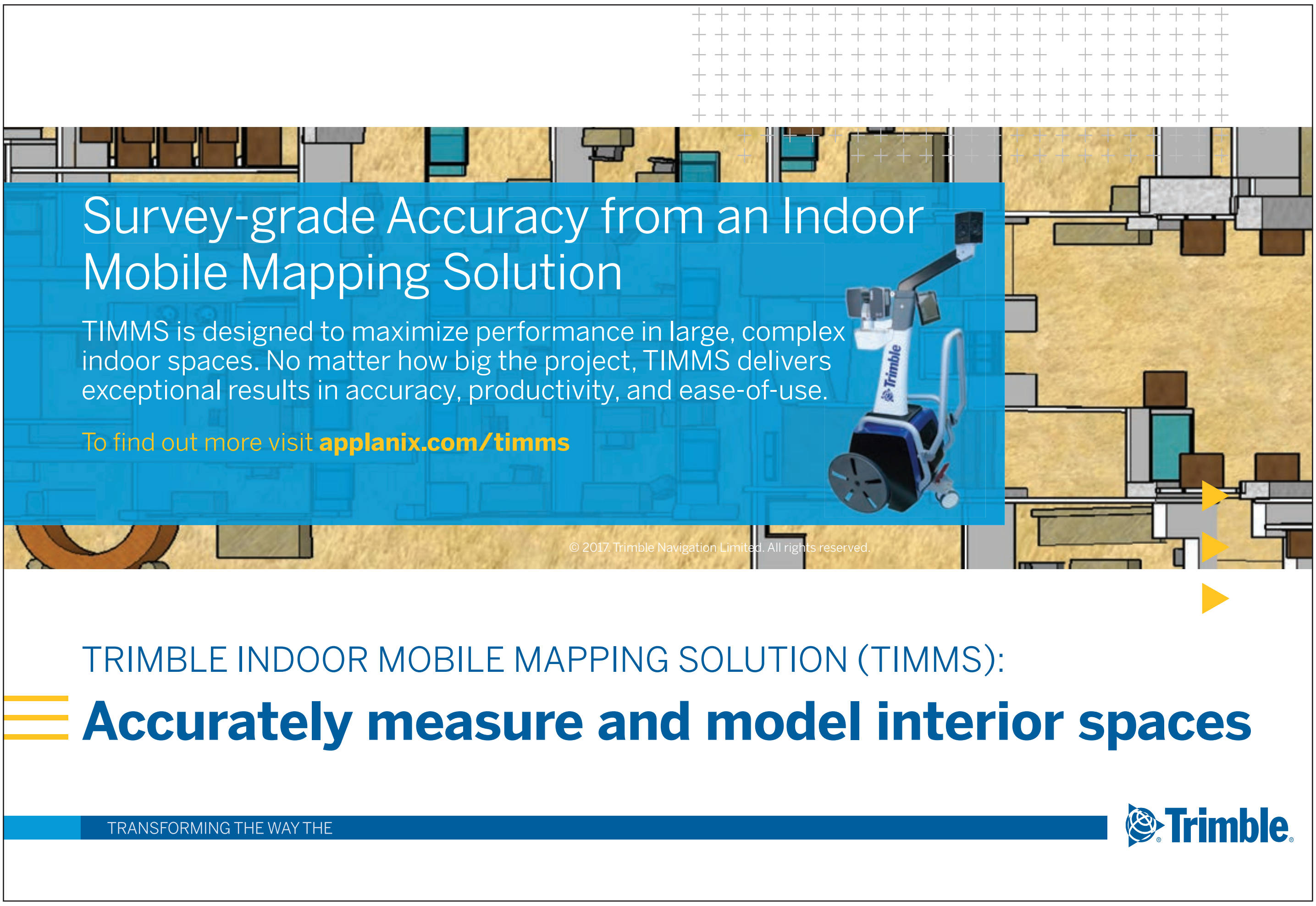
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▲ *Figure 4, Overlay of point cloud and panoramic imagery collected from the mobile laser scanning survey featuring the iconic Singapore Merlion.*

5). The platform – which is scheduled to be ready in 2018 – will contain both static and real-time data, allowing users to simulate present and future scenarios alike. 3D models generated from both phases of the SLA projects will make up a large proportion of the static data to be fed into the system. With the vast amount of sensor data to be incorporated into the static model, Virtual Singapore will form a digital to-scale model of a living, breathing city. Some of the key topics to be initially tackled in Virtual Singapore are renewable energy, waste management and neighbourhood walkability. Other potential applications include prediction of disease propagation and detailed analysis of both new and existing public transport routes.

LIVING LABORATORY

The Virtual Singapore platform has been described as a 'living laboratory' where a range of smart city initiatives can be trialled and perfected. Through its capabilities as a collaborative platform, Virtual Singapore will also facilitate communication between stakeholders from government, industry and the general public. Another key example is the space management application (named GISD) that AAM has developed for JTC Corporation, which is Singapore's principal developer and manager of industrial estates and their related facilities. GISD is a browser-based platform focusing on facility management. Functions include the ability to analyse available office space in a building and to build linkages with other JTC systems, such as property tax. This system incorporates 3D models from the SLA project for surrounding context, along with detailed models of the individual buildings, including internal features converted from existing BIM models. For JTC, this application is hosted on premise and accessed through the intranet. In other regions of the world, such as Australia and New Zealand, there is a large movement towards (internet-based) cloud platforms to support and embrace collaboration to aid in making informed decisions. AAM's GEOCIRRUS is an example of such a collaboration platform, in which technology is a key component in disseminating geospatial data to the appropriate stakeholders for action.

BUILD IT AND THEY WILL COME

Use cases such as Virtual Singapore and GISD are only the beginning. An article in *The Wall Street Journal* last year stated that "when such huge volumes of data are collected and cross-referenced, experts say, applications emerge that are difficult to imagine until the material is available in the first place". So we have a *Field of Dreams*-type scenario: "Build it and they will come". Data from phase two of the mobile mapping survey is currently being used by various organisations conducting trials at the One-North autonomous vehicle test site. In 2016 NRF released a grant call allowing government, private and research organisations to pitch ideas of what additional applications could benefit from accessing the 3D national map data. Singapore represents a unique environment of geographic and political stability which allow forward-thinking initiatives such as this to flourish. In this sense, Singapore truly is a living laboratory and test bed where technology is and will continue to be used to improve the lives of all citizens.

DEFINING 'SOMEWHERE'

Singapore has long served as a beacon for Southeast Asia in progress and innovation. With its advances and developments in smart city solutions, the city-state can now set examples for the rest of the world to follow. Everything that occurs in this world has one thing in common – it occurs 'somewhere'. Accurate, detailed and up-to-date geospatial information connected with sophisticated access platforms allow that 'somewhere' to be defined, leading to a myriad of applications and benefits. In this sense, geospatial information – or, in Singapore's case, the 3D national map – provides the framework or backbone for the smart nation initiative. ◀

▲ *Figure 5, Hands-on interaction with the Virtual Singapore platform at the World Cities Summit Exposition (July 2016).*

FURTHER READING

- Virtual Singapore: https://www.nrf.gov.sg/programmes/virtual-singapore
- Aerial 3D mapping of Singapore: http://www.aamgroup.com/resources/pdf/Geocoxion-smart-vision-for-cities.pdf

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SPECTRA PRECISION

AN INTERACTIVE 4D RECONSTRUCTION OF A HISTORIC BUILDING IN VIRTUAL REALITY

The Development of a **Virtual Museum** in Germany

A 'virtual museum' (VM) has the potential to greatly improve the experience of a traditional museum visit, adding the possibility to provide information in a new, entertaining and convenient way. Interactive digital visualisations in particular can increase the comprehensibility of a complex topic. Such an application has now been developed as part of a master's thesis for the Museum Alt-Segeberger Bürgerhaus in Bad Segeberg, Schleswig-Holstein, Germany. The whole building, the museum exhibition and six historic stages of construction have been reconstructed based on the capture of 3D data. Visitors can explore the historic building in a real-time 3D environment, both in a desktop application and in virtual reality (VR).

The Alt-Segeberger Bürgerhaus is the oldest building in Bad Seeberg, Germany. Constructed in 1541, the building has changed its form and function several times during its 475-year history. In collaboration with Nils Hinrichsen, historian and head of the museum, it was possible to identify the appearance of the building during six major periods of construction. It started as a small three-room house after a fire destroyed most of the town, including the previous building, in 1534. Several rooms were subsequently added to the building over the centuries. The facades and the interior design changed in line with the needs and possibilities of the corresponding eras. The last major renovation took place in 1963-64, when a museum was established in the building for the first time. Since 2012 it has been accommodating exhibitions about both the history of the city and the building as well as German culture (Figure 1).

Since 2011, there has been a cooperation between the museum and the HafenCity University Hamburg (HCU), whereby the museum building has been used in the practical education of students from the HCU's bachelor programme in geomatics. Students have recorded both the exterior and interior of the building and created 3D models for the purpose of learning photogrammetric 3D recording and visualisation techniques. This data forms the basis for the VM project.

3D MODELLING

The first step was to construct the building in its current state based on the data mentioned above. In order to optimise performance, the model was not calculated from the point cloud by meshing but constructed manually in AutoCAD instead. Thus a stable frame rate for visualisation could be achieved, even on standard computers, while still having a decent amount of significant object details included in the scenes.

The historic models were created using the model of the current state as a starting point and retracing the steps of every known reconstruction change (Figure 2) using historic sources. Furthermore, the buildings in the museum's surroundings were modelled with non-textured, simple geometric shapes to provide an environmental context for visitors standing outside the museum. Additionally, the most important parts of the exhibition were modelled for later integration

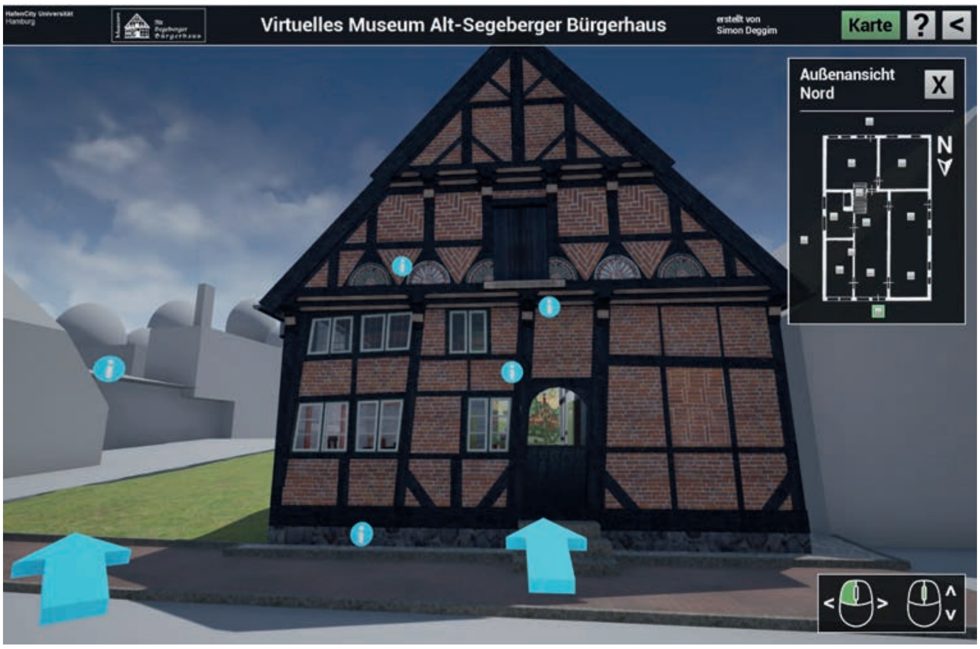
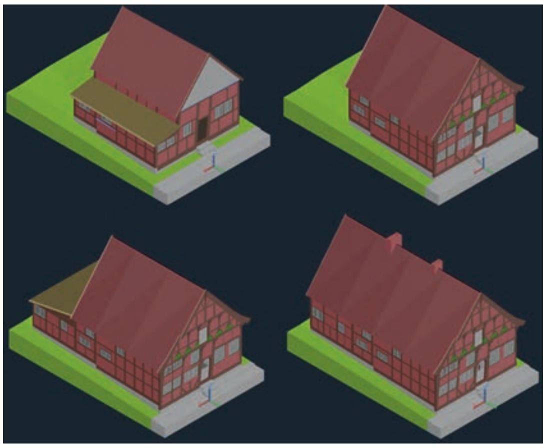


Figure 1, Front view of the digital Alt-Segeberger Bürgerhaus in the final program.



▲ *Figure 2, CAD models of the first four states of construction. From top left to bottom right: 1541, 1585, 1805, 1814.*

▲ *Figure 3, Menu view from the final program.*

into the building interior. The total triangle count of all objects amounts to approximately 100,000 triangles, which is a good basis for a low-cost, real-time visualisation application.

GAME ENGINE AND PROGRAMMING

The interactive part was developed using the Unreal Engine 4 game engine. Game engines provide very high performance for real-time rendering and ever-increasing support for virtual-reality systems. For the desktop version, several fixed positions were placed both inside and outside the building. Users can look around freely from any position and can switch between positions with a short animated transition or can use direct teleportation by clicking on the desired position on a miniature overview map. The interaction with the environment is provided by a total of 52 clickable information signs. Each sign opens a menu with further information about the object of interest. The menu usually includes a text and a sizable photo (Figure 3). It is also possible to implement other media such as videos and separate small 3D models within the menu.

The main feature of the VM is the visualisation of the construction history. Designed as a 'model within the model', the historic states of the building can be explored by walking around them and activating animations which provide an exploded view of every state of construction (Figure 4). Alternatively, individual changes in the appearance of the building can be displayed slowly, from one state to the next, accompanied by comments about the main changes during the construction period.

VIRTUAL REALITY

The VR version of the VM was created using HTC Vive, which has been available on the market since April 2016. The fixed positions were replaced by a free navigation, either via teleportation or direct walking. Two motion controllers were also used to interact with the environment; one controller fulfils the teleportation function and contains a laser beam to activate and interact with the menus, while the other contains the menu screens and the miniature overview map. The freedom of perspective and the improved sense of scale makes the VR museum an immersive 3D environment. This allows an even deeper analysis of the 4D model of the building's evolution by giving visitors the possibility to actually stand inside the building while it changes around them (Figure 5).

RESULTS AND CONCLUSIONS

The final desktop version of the program is 500MB in size and is executable on Windows-OS without software installation. This extends the field of application from the museum itself to most personal computers (PCs), enabling visitors to purchase the program and further deepen their knowledge about the exhibition topics they have seen.

▲ *Figure 4, Exploded view from the third state of construction in the menu for the building history.*

FURTHER READING

• Kersten, Th., Tschirschwitz, F., Deggim, S., 2017. Development of a Virtual Museum including a 4D Presentation of Building History in Virtual Reality. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-2/W3, 3D Virtual Reconstruction and Visualization of Complex Architectures, 1-3 March 2017, Nafplio, Greece, Editor(s): D. Aguilera, A. Georgopoulos, T. Kersten, F. Remondino, and E. Stathopoulou, pp. 361-367. Kersten,

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• Tschirschwitz, F., Kersten, Th., Zobel, K., 2014. Interactive 3D Visualisation of Architectural Models and Point Clouds Using Low-Cost-Systems. In: Progress in Cultural Heritage. Documentation, Preservation, and Protection, Lecture Notes in Computer Science (LNCS), Volume 8740, Springer International Publishing Switzerland 2014, 268-278.

▲ *Figure 5, Test demonstration of the VR application.*

The VR version of the program has been demonstrated on several occasions, including at Intergeo 2016 in Hamburg. The very positive feedback showed the promising potential of such applications, which is particularly high in – but not limited to – the museum context. In theory, any application which benefits from a realistic representation of the environment and is improved by an immersive experience can benefit from the use of interactive VR. This can increase the entertainment aspect, a person's understanding and their motivation to deal with an unknown topic, and the approach can help to convey information in presentations, promotional and/or educational settings. ◀

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NEW TECHNOLOGY CAN SIGNIFICANTLY IMPROVE BIM

Increasing Information in **Building Models**

Since the advent of building information modelling (BIM) software in the early 2000s, 3D modelling has significantly improved building design. With regular updates, BIM can also ensure that, during construction, the work progresses according to the design. In practice, however, BIM usually stops once construction starts. This can mostly be attributed to the complexity and cost of gathering accurate and current data needed to update the digital models. The German firm NavVis GmbH is a Munich-based start-up that has developed technology which overcomes these barriers by reducing the cost and increasing the efficiency of capturing and comparing data of physical structures to design models. This innovation has the potential to significantly increase the scope and efficiency gains of BIM.

Capturing data for building models of existing structures is a time-consuming process that requires a high level of skill. The data is typically collected by a professional surveyor using a static tripod-mounted laser scanner. To improve this process, NavVis developed the 3D Mapping Trolley, a 3D scanning and mapping tool that significantly increases the speed and efficiency of capturing indoor data (Figure 1). The trolley is equipped with three lasers, six cameras and several antennas, and it automatically captures every inch of space in 3D as it is moved around. The measurements captured generate point clouds (Figure 2) that are later also used to create the navigation graphs that enable indoor routing. The photographs captured are subsequently processed by NavVis software to create panoramic images. This process requires nothing more than an operator pushing the trolley through the space to be captured. The NavVis M3 Trolley is equipped with a touchscreen that provides real-time feedback to show which areas have been scanned, making it easy to identify areas that still need to be mapped.

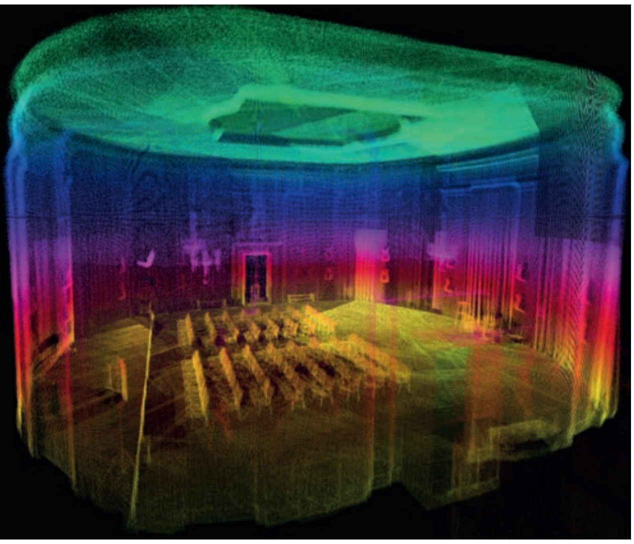
3D VISUALISATION SOFTWARE

Of course, digital building data is only valuable if it is accessible to the people who need to work with it. For this reason, NavVis developed browser-based software, known as IndoorViewer, which displays 3D visualisations of the data captured by the M3 Trolley. Crucially, the IndoorViewer software automatically generates the 3D visualisation, eliminating the need for specialised software. The 3D images can be viewed and navigated from any device, much like Google StreetView. IndoorViewer, however, has more functionality than Google StreetView; for example, it displays coloured 5mm-resolution point clouds that can be used to measure distances between individual points and the navigation graph also enables routing. There are a number of other useful features, such as being able to add detailed descriptions of objects in the scene.

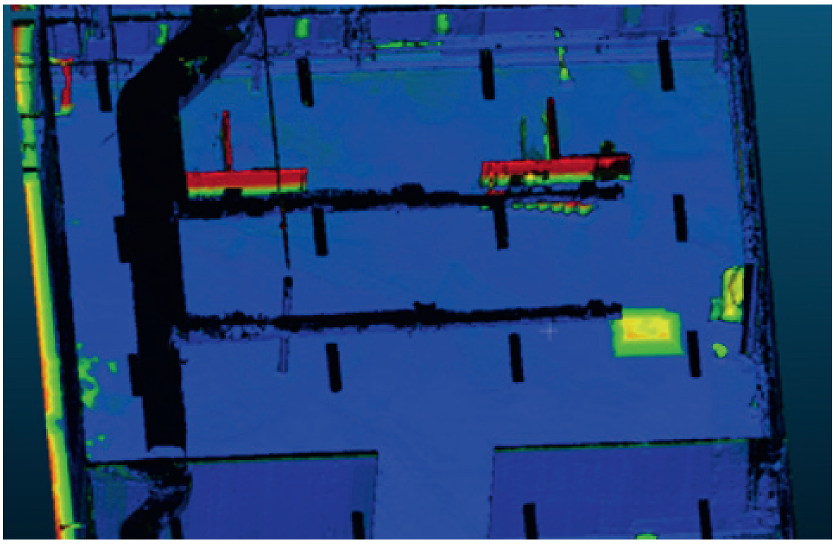
BIM ENHANCEMENT

The automated scanning and mapping enabled by NavVis technology both supports and enhances traditional building information models. Currently, BIM is most often used in the design phase of a building project, but the construction phase is equally important if the design is to be implemented according to plan. The M3 Trolley can be used as a data-capturing tool to update and compare BIM models on a regular basis. Once the data has been captured there are two options for comparing the models:

▲ *Figure 1, M3 indoor automated 3D scanning and mapping trolley.*

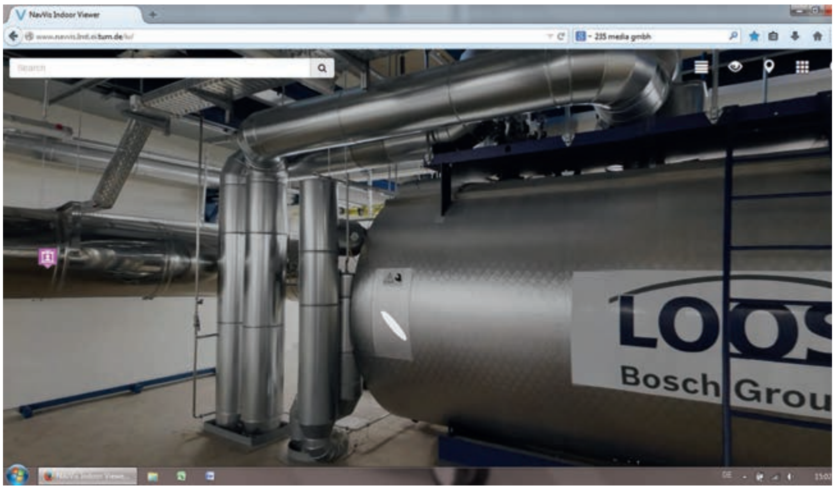


▲ *Figure 2, Point cloud as generated by the M3 Trolley.*

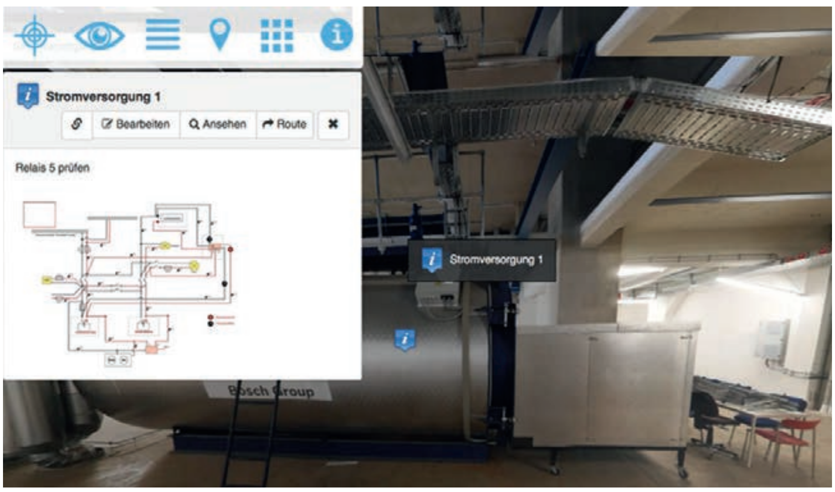


▲ *Figure 3, Difference model (Red = large difference, yellow = small difference).*

1) With a virtual walkthrough in IndoorViewer which gives a detailed view of progress and eliminates the time and cost of travelling to the site; 2) By comparing point clouds in IndoorViewer and using colours to detect differences. Red is used for large differences and yellow for smaller ones (Figure 3). Based on this information, construction timetables and building models can be adapted accordingly and damage or non-adherence to the plan is detected much sooner.



▲ *Figure 4, Building assets in the IndoorViewer software.*



▲ *Figure 5, Tagging an object in IndoorViewer.*

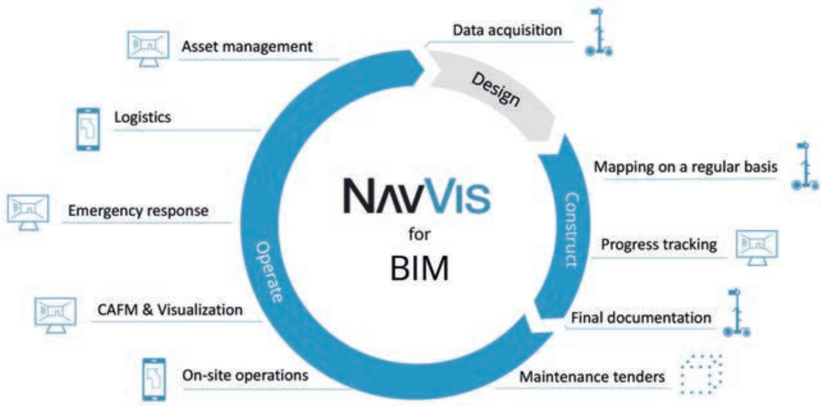
The IndoorViewer software also enhances the building modelling process. The BIM database can be connected to IndoorViewer and specific details can be 'dropped' into the software and made available through the 'point of interest' feature. This means that anyone involved in the building design and construction team can easily access this information. Unlike BIM software IndoorViewer does not require specialised training, plus it can be accessed from a tablet or smartphone. Hence, after processing, the information is also available on site.

Using the photographs in IndoorViewer also significantly improves the quality of the data available in the BIM model by providing a much more detailed overview of an indoor space than is obtained with scanning only. Users are able to zoom in on the high-resolution panoramic images. This enables details about specific materials used to be added to the BIM model (Figure 4) by checking IndoorViewer, without having to visit the site after the initial scanning has been done.

After the project is completed, the 3D construction documentation gathered in this way can be used to fully digitise building operations and facility management. The IndoorViewer software provides building owners and operators with a virtual database of building assets (Figure 5) that can be tracked and monitored remotely. Additional information can be added to specific points and objects with a mouse click, which is especially useful for cataloguing building inventory. To protect the built asset, the 3D documentation can be used in insurance claims while the routing information can be used to reduce emergency response time. The routing option also optimises internal logistics, both for employees and external partners who can deliver shipments and provide services to a precise location. Building operators can even create and assign maintenance tickets with high-resolution imagery and an exact location reference.

SHAPING THE FUTURE OF BUILDINGS

As the benefits of building models continue to gain recognition, the adoption of BIM will continue to grow. Many national governments – including of the USA, Germany and the UK – have already acknowledged the value of BIM and have begun to mandate digital modelling in the design phase of large construction projects. The evolution of BIM through NavVis technology increases the scope for deriving benefits from digital modelling, effectively paving the way for BIM to become even more valuable (Figure 6). ◂



▲ *Figure 6, NavVis products in the BIM cycle.*

ABOUT THE AUTHOR

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EFFECTIVE SURVEYING TOOL FOR THE SHALLOW WATER ZONE

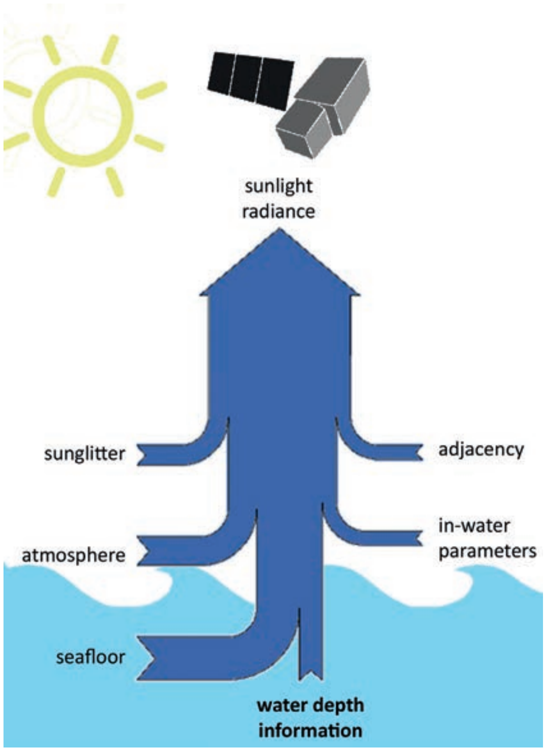
The Increasing Importance of **Satellite-derived Bathymetry**

The objective of this article is to provide an overview of the Satellite Derived Bathymetry methods, how data can be integrated into survey campaigns and finally to showcase three use cases. Bathymetric data in the shallow water zone is of increasing importance to support various applications such as safety of navigation, reconnaissance surveys, coastal zone management or hydrodynamic modelling. A gap was identified between data demand, costs and the ability to map with ship and airborne sensors. This has led to the rise of a new tool to map shallow water bathymetry using multispectral satellite image data, widely known as Satellite Derived Bathymetry (SDB).

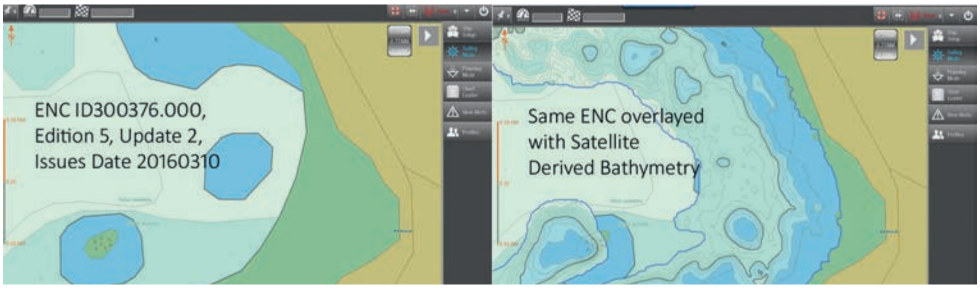
Strictly speaking the methods to derive information on seafloor topography using reflected sunlight date back to the 1970's but it has required iterative improvements of algorithms, computational power, satellite sensors and processing workflows in order to provide the current state of the art. Today, a range of different methods exist under the umbrella of the SDB term. However, as with traditional survey methods it is imperative to understand the advantages, disadvantages and overall feasibility in order to evaluate the suitability and fit-for-purpose of a given SDB application.

BATHYMETRIC DATA PRODUCTION

Historically, empirical methods were used, which require known depth information over the study area. By comparing these known depths with the satellite signal, a statistical relationship can be derived that adequately describes depth as a function of the signal. Aside from requiring known depth data, these methods will only work for a given satellite image. A subsequent satellite scene, even of the same location, may contain different atmospheric and in-water parameters, and thus the statistical relationship needs to be re-calculated. Another aspect of these methods is that the statistical relationship is only valid for one water type and one seafloor type. Therefore, when an area contains different types such as coral, sediment, algae and rubble, the statistical relationship needs to be calculated for each of these substrate types. The correct formula then needs to be applied to each pixel in the image, i.e. the algorithm needs to be informed a-priori which substrate type it is encountering in that image pixel. This brings the problem full circle back to one of the fundamental challenges of satellite-derived bathymetry: how do you know that a darker signal is due to deeper water, a darker substratum, or a bit of both? These methods can still be useful as they are relatively straightforward to implement (see The IHO-IOC GEBCO Cook Book, 2016). Physics-based methods on the other hand, do not require known depth information for the study area, and can therefore be applied independent of satellite data type and study area. These methods rely on fully describing the physical relationship between the measured light signal and the water column depth. Optical variability in the atmosphere and water column is accounted for within the algorithm inversion, and no 'tuning' to known depths is required. Therefore, an area can be targeted which is physically inaccessible and for which there is no previous information known. Not surprisingly, these physics-based methods require more sophisticated algorithms and powerful processing capacity.



▲ *Figure 1, The diagram shows the relative amount of measured light energy which contains water depth information.*



▲ *Figure 2, Current ENC (March 2016 ,left) and overlaid by SDB data (right) showing shoals misplacement and low details of the ENC compared to the Satellite Derived Bathymetry-ENC.*

The benefit is that they typically prove to be more accurate, especially in areas with varying substrate types, turbidity and/or atmospheric conditions. This is of particular importance because only a small fraction of the sunlight recorded by the satellite's sensor originates from the source which can be associated with water depth. Depending on the wavelength channel, this fraction varies typically between less than one and up to a maximum of 20%, going from near-infrared to green/blue light energy. It is critical to accurately account for the other sources of light energy in order to separate out the relevant water column depth contribution to the measured signal.

DATA INTEGRATION

The integration of SDB data into daily use can be straightforward if the bathymetric data quality and delivery formats follow best practice. Hence the file formats typically follow industry standards (OGC) and enable a direct use in current GIS or online visualization tools through Web Mapping of Coverage (WMS, WCS) interfaces, hydrographic software or scripting tools. ISO conform metadata including important information on tidal corrections, processing levels and date and time of satellite recording are essential for geodata and are mandatory for all SDB data.

Furthermore, it is important to understand the uncertainties in the data as well as the limitations of SDB for a given application in order to integrate the data appropriately. Such information needs to be expressed in uncertainty layers which should ideally include quantitative information. For some applications, such as safety of navigation, additional information such as the ability to identify obstructions of different sizes needs to be included as well.

SAFETY OF NAVIGATION

Satellite Derived Bathymetric information supports safety of navigation by providing up-to-date and high resolution grids of the shallow water zone. This is of particular importance in areas with outdated charts or dynamic seafloor. In addition to the bathymetric information, of particular importance is the identification of obstructions which could be a risk to navigation.

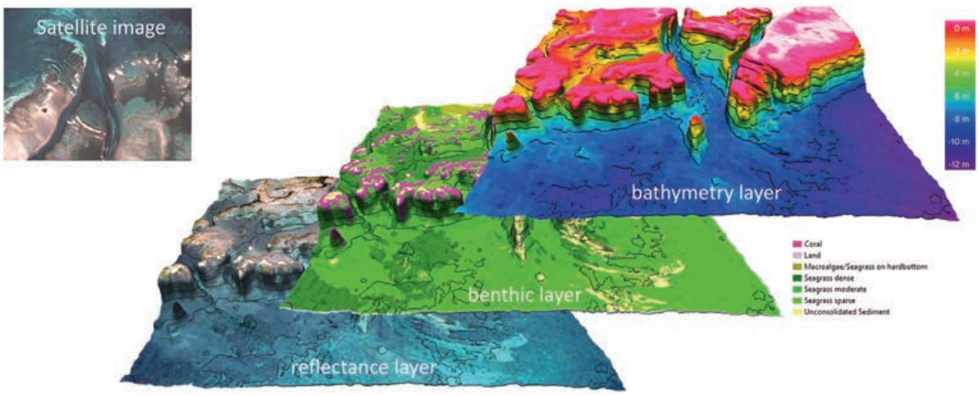
Ideally the bathymetric data are provided in the form of digital nautical charts (ENCs) and ECDIS (Electronic Chart and Display System) as the main navigation device which represents the standard for the majority of vessels. Satellite Derived Bathymetry data cannot immediately be used for navigation with ECDIS – however, it can serve as an additional data source when updating the bathymetric information of nautical charts (paper or digital). ENC Bathymetry Plotter, a recently finished software product of SevenCs' chart production suite, represents a powerful tool to create depth-related information objects for inclusion in ENCs which fulfill all relevant IHO quality standards. SevenCs and EOMAP have teamed together to provide an innovative service, the combination of up-to-date shallow water bathymetry provided as a standard ENC. This can therefore be used immediately on board vessels. An update of official ENCs which include Satellite Derived Bathymetric data, is therefore possible at the commencement of a voyage, but also during the vessel's journey - via satellite communication - and therefore allows for the planning of more efficient shipping routes, increased safety as well as an improved situational awareness to react to a forced change of the shipping route (e.g. weather events or other threats).

It is obvious that the need for updating ENCs for safety of navigation is of importance for poorly mapped areas. It should not be understood to replace recent and high resolution and quality ENCs if available.

In 2016 bathymetric data was provided to Van Oord covering several atolls in The Maldives. The data were used to enhance safe navigation by charting all shoals which might or might not be indicated on Electronic Navigation Charts. This contributed to efficient planning of the project's activities. Data were provided within few days after ordering covering an area of several hundred sq km, which showcases the flexibility of the technique.

RECONNAISSANCE SURVEY

Satellite Derived Bathymetry can play a role as a reconnaissance survey tool in applications ranging from shallow water seismic surveys, coastal engineering to optimal planning of acoustic surveys. Although different in usage, all of these applications have in common that they require bathymetric data which is (a) spatial, (b) high resolution, (c) rapidly available and (d) affordable within a typical planning phase budget. Reconnaissance surveys are usually relevant for areas which are poorly surveyed, where charts are outdated or where bathymetric data are simply not accessible. Many examples for these kinds



▲ *Figure 3, Baseline data on seafloor information based on satellite images and physics based algorithms.*

of applications have already been published and two showcases are summarised in the following paragraphs.

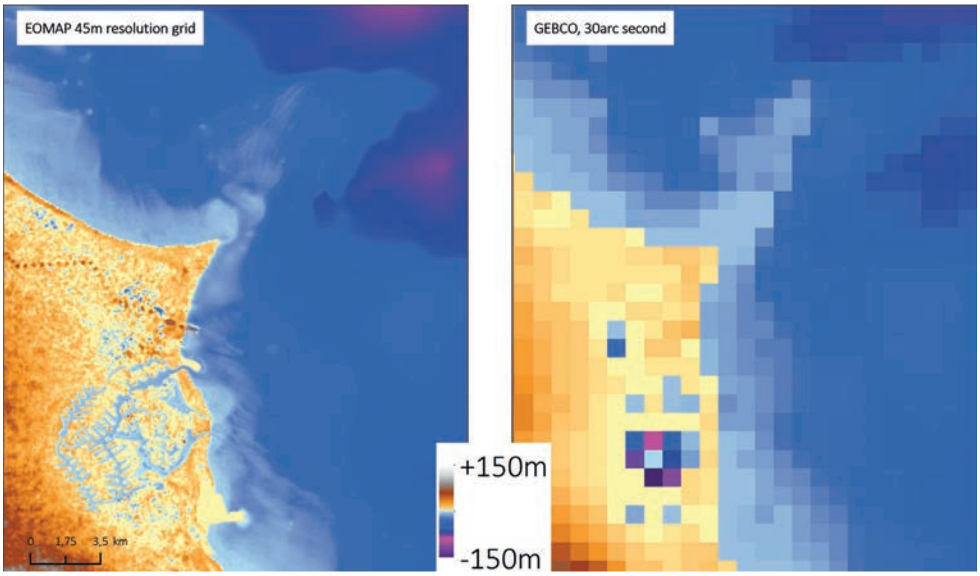
In 2013, EOMAP mapped the shallow water bathymetry of the entire Great Barrier Reef, Australia, at 30m grid resolution. This was the first depth map of its kind for the entire Great Barrier Reef, and also the largest optical SDB dataset ever made. In 2014 Shell published a paper on the use of EOMAP's Satellite Derived Bathymetry (delivered at 2m grid resolution) to support their shallow water seismic campaign in northwest Qatar (Siermann et al. 2014). SHELL summarised the benefits of using the satellite techniques over more traditional methods by citing a 1 Million USD costs savings and very timely delivery of the data.

Basis Data for Hydrodynamic Modelling

Hydrodynamic modelling exercises, such as generating tsunami forecast models, are typically not the type of applications with budgets that allow for purchasing bathymetric survey campaigns using more traditional methods. Commonly, very coarse resolution bathymetric grids such as GEBCO are used instead, but this has limited validity in coastal areas. By using Satellite Derived Bathymetry, shallow water depth data can be derived at fit-for-purpose grid resolution to within a limited budget. As a standalone dataset it does not fulfil the modellers requirements but when merged with up-to-date information on the coastline –(also derived from the satellite imagery), survey and chart information, a seamless shoreline-to-deep-water dataset can be created, which greatly improves on currently available datasets. Such a dataset was created for the Gulf region, which now serves as bathymetric dataset for tsunami modelling in the area.

FUTURE PERSPECTIVES

Over the intermediate term it is expected that satellite-derived mapping of the seafloor will continue to be increasingly accepted and integrated as a survey tool - as is now already the case for a number of innovative user groups. Developments are still needed in areas such as how to best quantify uncertainties and small scale obstructions. One likely development will be the mutlitemporal and sensor agnostic mapping approach, which can be oversimplified as: use all available image data to the best possible extent and quality. With the advances of cloud computing, physics-based algorithms and an increasing selection of image data, this is would be a natural evolution for Satellite Derived Bathymetry. ◀



▲ *Figure 4, Example of the seamless multisource bathymetric grid for the Persian Gulf, including Satellite Derived bathymetric data (left) and the GEBCO dataset (right).*

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MORE INFORMATION

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Dr Magnus Wettle, managing director for EOMAP Australia Pty Ltd. With more than 15 years experience in aquatic remote sensing, he has previously held positions at the University of Queensland, Geoscience Australia and CSIRO.

CATALOGUING THE INTRICACIES OF OXFORD UNIVERSITY

3D Handheld Scanning of Historic Buildings

For institutions of immense historical importance, regular upkeep is vital to preserve the structural integrity of the buildings. The ability to map the intricate environments in detail is useful to identify faults and features, and to point out areas which require attention to protect them. How can the structural complexities of a medieval building be accurately catalogued within a limited time frame? The fully operational, busy academic establishment of Oriel College, part of the University of Oxford in the UK, forms a great challenge in this respect. This article gives insight into how a handheld mobile mapping tool with 3D simultaneous location and mapping (SLAM) technology was used to compile floor plans and elevation drawings of over 200 rooms in both a timely and a cost-effective manner.

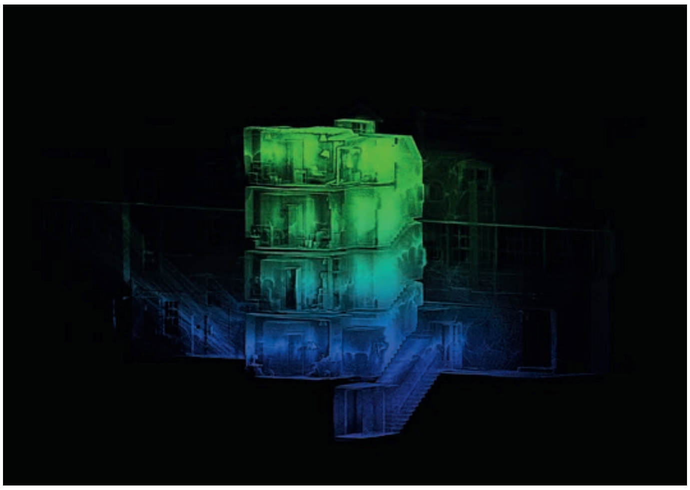
Oriel College is blessed with alumni including two Nobel laureates, one of them being a founding member of the Oxford Movement (the Catholic revival in the Church of England). While the academic prowess of the college is not in any doubt, the structural integrity of an institution that was founded in 1326 is naturally less certain. Located in the heart of Oxford and made up of a myriad of buildings, with around 200 rooms across five storeys fulfilling a variety of uses, Oriel College presented unique scanning challenges.

The custodians of Oriel College needed to assess the physical 'health' of their 'Island Site', a hidden-away part of the college only usually accessible through two entrances, one of which is a tunnel with step access. The likelihood of encountering unforeseen issues with the buildings (particularly when a structure has been added to and developed over the years) was high. As such, accurate floor plans and elevation drawings needed to be created based on mobile mapping data, displaying exactly how the building was built. This included all quirks and irregularities that are of interest for future structural improvements or changes to the buildings. A challenging handheld mobile mapping project was performed to create these maps and CAD drawings of this part of the University of Oxford.

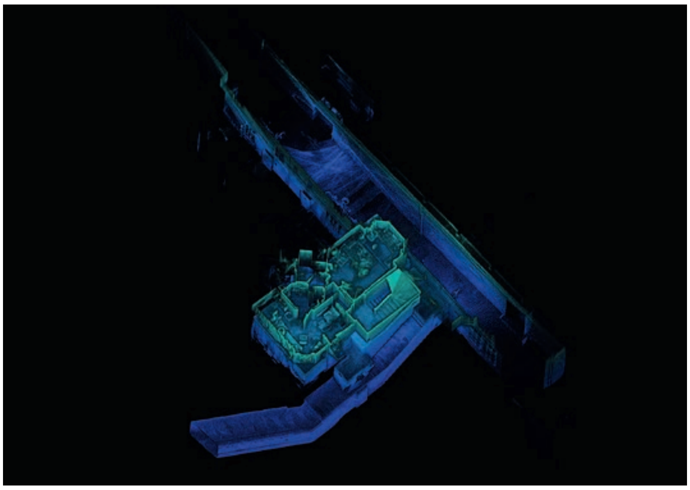
TIME PRESSURE

The mobile mapping project was challenging not only due to the age and intricacy of the structures, but also due to the fact that the mapping needed to take place in as little time as possible to avoid disruption to daily operations. Meanwhile, it was important to obtain sufficient data without compromising on the accuracy of the results.

With some historical sites, it is possible to choose a time to scan when the buildings

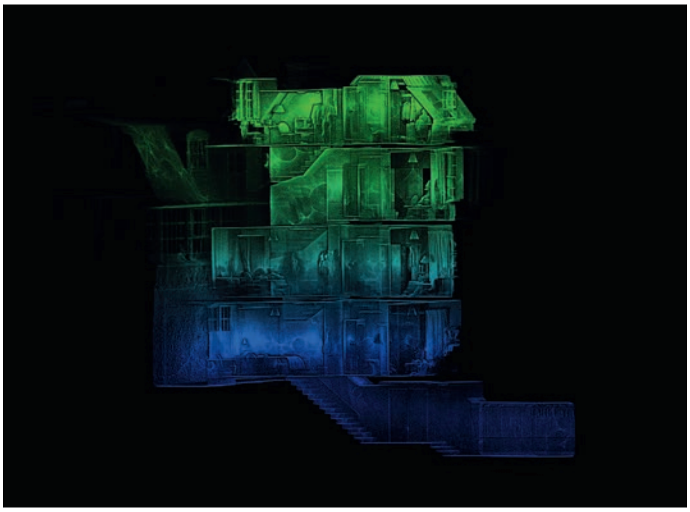


A cross-section scan of an Oriel College building.



A 3D point cloud scan showing an overhead view of the college.

▲ *A ground floor plan showing the complex network of buildings.*



▲ *A 3D point cloud scan of Oriel College's interior space.*

are closed to the public or not in use. Oriel College, however, is a world-class teaching, learning and research institution that has visitors, staff, students and alumni present at all times of day, all year round. In fact, many of the rooms would be in use during the scan as it was exam time, or serving as student accommodation with the associated privacy constraints. With over 40 fellows, 300 undergraduates and 160 graduates occupying the college, the mapping needed to be as swift as possible to minimise disruption.

UNCONVENTIONAL LAYOUT

Due to the unusual shape of the building, with its unconventional layout and complex network of rooms, it would prove difficult and time-consuming to survey with traditional static scanning methods (as this would require multiple individual set-ups and increased post-processing work). Added to the fact that static surveying methods can be more intrusive and require the team to stay significantly longer on site, it was also recognised that physically collecting data by measuring the space with traditional tools such as laser distance measurers or tape measures would not be suitable for Oriel College.

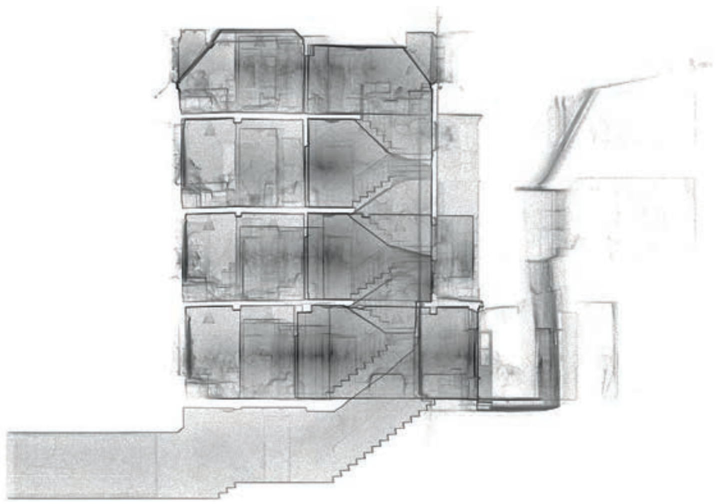
SLAM TECHNOLOGY

The chosen tool was the GeoSLAM ZEB-REVO, a handheld, lightweight, mobile indoor mapping tool that can record over 43,000 measurement points per second. The ZEB-REVO employs a very robust 3D simultaneous localisation and mapping (SLAM) algorithm, which is at its best in complex, enclosed, multi-level environments. This SLAM technology utilises data from a Lidar sensor and an IMU to identify unique three-dimensional (3D) structures within the survey environment, and creates a point cloud of these structures. This iterative process occurs constantly as the user walks through the environment and builds up a 3D model of the space. Since the ZEB-REVO unit contains an IMU, it does not require a GPS signal for positioning. As well as recording heritage buildings, the ZEB-REVO is used in other projects for generating footprints, estate agency requirements and scanning to building information modelling (BIM). Without the need for comprehensive training to use the device, the team was able to 'pick up and go' with the ZEB-REVO tool, saving additional preparation time for any members of staff previously unfamiliar with the technology. The team's previous experience indicated that GeoSLAM ZEB-REVO would significantly cut time and costs, while still reaching an average accuracy level of 15mm, making it a very suitable technology for this project.

RESULTS

Thanks to the scanner's speed, the space could be surveyed in a very short amount of time, which was particularly important due to the limited time available in certain rooms. Using the ZEB-REVO around 200 rooms were scanned, amounting to 12,000m^2 in total. Across five days, 12 individual rapid ZEB-REVO scans were completed, each taking around half an hour. Taking into account ten days to produce the CAD drawings, the entire project was completed in around half of the total time that would have been required using static equipment, reducing an estimated 44 days down to 24.

▲ *A floor plan of the first floor in Oriel College.*



▲ *An elevation drawing of Oriel College.*

The final drawings were revelatory, showing just how irregularly the college buildings were arranged. As an institution with such a long history, it was also fascinating to discover how the college has been adapted and added to over time by different caretakers and building managers. Representing the buildings in their truest form (3D) made it possible to highlight the faults, features and façades that required attention or future planning to preserve.

NEXT STEPS

Using non-intrusive and accurate technology like the ZEB-REVO provides detailed accounts of a facility's structural limitations. The next step in this project is the generation of complex BIM-ready 3D models from this 3D scan data. Such models can be used as a 'digital twin' of the building, allowing for building modifications and adaptations to be worked into the 3D model – either before or after the actual works have taken place. The use of geomatics technology has enabled the preservation of this historical institution from a heritage perspective, as well as ensuring that Oriel College can continue to provide education of the highest possible order for many years to come.

FURTHER READING

For more information on GeoSLAM's ZEB-REVO, visit www.geoslam.com. ◀

ABOUT THE AUTHOR

Peter Maxwell is an expert in the provision of topographical surveys, measured building surveys and underground utility land surveys and works as an IT manager at Midland Survey Ltd in the UK.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WHAT IS A BLOCKCHAIN AND HOW IS IT RELEVANT FOR GEOSPATIAL APPLICATIONS?

Blockchain in Geospatial Applications

A blockchain is an immutable trustless registry of entries, hosted on an open distributed network of computers (called nodes). It is potentially safer and cheaper than traditional centralised databases, is resilient to attacks, enhances transparency and accountability and puts people in control of their own data. Blockchain technology will be explained more thoroughly further below and particularly in the web version of this article.

As an immutable registry for transactions of digital tokens, blockchain is suitable for geospatial applications involving data that is sensitive or a public good, autonomous devices and smart contracts.

USE CASES

Here are some geospatial use cases:

1. Public-good data such as street maps, parcels, terrain models, aerial footage or sea maps – made publicly available without a central hub that can restrict access to the data; contributors to the map are rewarded with tokens; a public record can be kept of changes and contributions.

2. IoT – autonomous devices & apps. Devices that negotiate with and pay each other, such as drones that negotiate use of air space, self-driving cars that negotiate lane space or pay for road usage, mobile/wearable devices that pay for public transportation; apps similar to Uber and Airbnb that connect clients and providers without a middleman.

3. Land ownership – land/real-estate ownership can be registered on a blockchain; corruption is rendered nearly impossible; people in developing countries can register land ownership themselves using inexpensive mobile devices without the need for slow or expensive overheads.

The use cases are discussed further below. The author has given a few short talks about this topic at various conferences, including at the international FOSS4G conference in Bonn, Germany, 2016.

PUBLIC-GOOD DATA

Over the past two decades, 'public-good' geospatial data has generally become much easier to get hold of, having originally been very inaccessible to most people. Gradually, the software to display and process the data became cheaper or even free, but the data itself – data that people had already paid for through their taxes – remained inaccessible. Some national mapping institutions and cadastres began distributing the data via the internet, although mostly with a price tag. Only in recent years have a few countries in Europe made public map data freely accessible. In the meantime, projects like OpenStreetMap have emerged in order to meet people's need for open data. It is hardly a surprise, then, that a myriad of new apps, mock-ups and business cases emerge in a region shortly after data is made available to the public there.

TRULY PUBLIC OPEN DATA

One of the reasons that this data has remained inaccessible for so long is that it is collected and distributed through a centralised organisation. A small group of people manage enormous repositories of geospatial data and can restrict or grant access to it. This is where blockchain and related technologies like IPFS can enable people to build systems where the data is inherently public, no one controls it, anyone can access it, and anyone can review the full history of contributions to the data.

Would it be free of charge to use data from such a system? Who would pay for it? Time will tell which business model is the most sustainable in that respect. OpenStreetMap is free to use, it is immensely popular and yet people gladly contribute to it – so who pays the cost for OSM? Bear in mind that there's no such thing as 'free data'. For example, the 'free' open data in Denmark today is paid for through taxes. So, even if it would cost a little to use the blockchain-based data, that wouldn't be so different from now – just that no one would be able restrict access to the data, plus the open nature of competing nodes and contributors will minimise the costs.

AUTONOMOUS DEVICES & APPS

Uber and Airbnb are examples of consumer applications that rely on geospatial data and processing. They represent a centralised approach where the middleman owns and controls the data and charges a significant fee for connecting clients and providers with each other. If such apps were replaced by distributed peer-to-peer systems, they could be cheaper and give their users full control of their data. There is already such an alternative to Uber called Arcade.City.

An autonomous device such as a drone or a self-driving car inherently runs an autonomous application, so these two concepts are heavily intertwined. There's no doubt that self-navigating cars and drones will be a growing market in the near future. Uber and Tesla have big ambitions regarding cars, drones are being designed for delivery of consumer products (Amazon), and drone-based emergency response (drone defibrillator) and imaging (automatic selfie drone 'Lily') applications are emerging. Again, distributed peer-to-peer apps could cut out the middleman and reliance on third parties for their navigation and other geospatial components.

LAND OWNERSHIP

Property is a moral, philosophical concept of assets acquired through voluntary transactions or homesteading. This perspective stretches at least as far back as John Locke in the 17th century. Such justly acquired property is reality, whereas law, governance services and computer code are systems that attempt to model reality. When such systems don't fit reality, the system is wrong and should be dismissed, possibly adjusted or replaced.

For the vast majority of people in many developing countries, there is no mapping of parcels or proof of ownership available to the actual landowners. Christiaan Lemmen, an expert on cadastres, has experience from field work to map parcels in developing countries such as Nigeria, Liberia, etc., where corruption can be a big challenge within land administration. In his experience, however, people mostly agree on who owns what in their local communities. These people often have a need for proof of identity and proof of ownership for their justly acquired land in order to generate wealth, invest in their future and prevent fraud – while they often face problems with inefficient, expensive or corrupt government services. Ideally, we could build inexpensive, reliable and easy-to-use blockchain-based systems that will enable people to map and register their land together with their neighbours – without involving any government officials, lawyers or other middlemen.

GEODESIC GRIDS

It has been suggested to use geodesic grids of discrete cells to register land ownership on a blockchain. Such cells can be shaped, e.g. as squares, triangles, pentagons, hexagons, etc., and each cell has a unique identifier.

In a traditional cadastral system, parcels are represented with flexible polygons which allows users to register any possible shape of a parcel. Although a grid of discrete cells doesn't allow such flexible polygons, it has an advantage in this case a: each digital token on the blockchain (a 'Landcoin') can represent one unique cell in the grid. Hence, whoever owns a particular Landcoin owns the corresponding piece of land. Owning a such a Landcoin means possessing the private encryption key that controls it – which is how other cryptocurrencies work. In order to represent complex and high-resolution geometries, it is preferable to use a grid which is infinitely sub-divisible so that ever-smaller triangles, hexagons or squares, etc., can be tied together to represent any piece of land. A digital token can also be infinitely sub-divisible. For comparison, the smallest unit of a Bitcoin is currently a 100-millionth – aka a 'Satoshi'. If needed, the core software could be upgraded to support even smaller units.

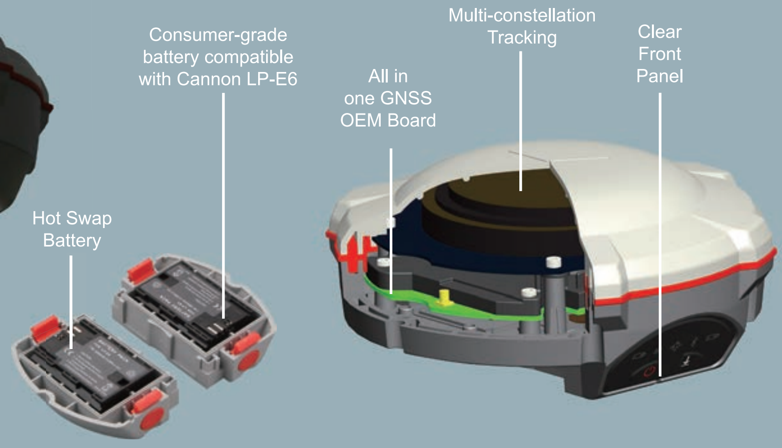
WHAT IS A BLOCKCHAIN?

A blockchain is an immutable trustless registry of entries, hosted on an open distributed network of computers (called nodes). It is potentially safer and cheaper than traditional centralised databases, is resilient to attacks, enhances transparency and accountability and puts people in control of their own data.

FURTHER READING

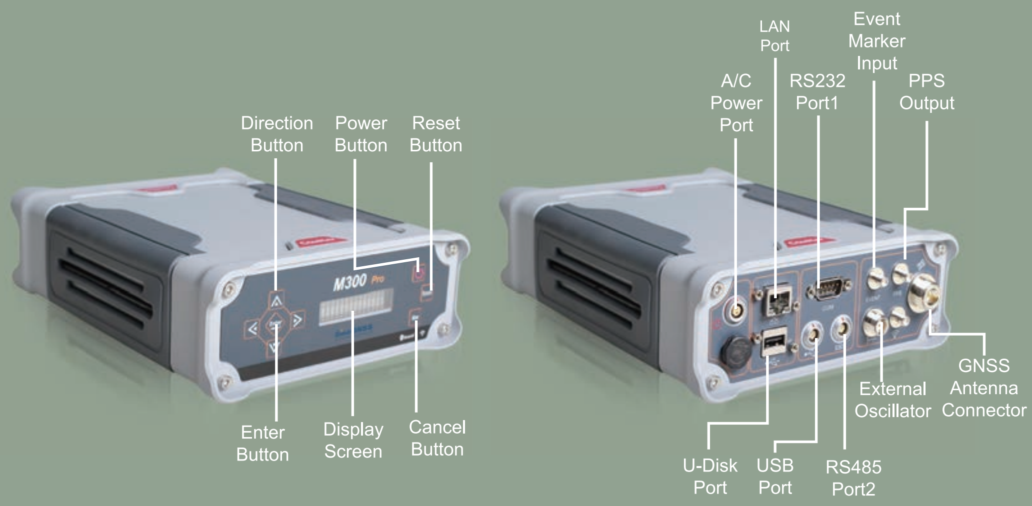
Read the extended version of this article here: https://www.gim-international.com/content/blog/blockchain-in-geospatial-applications-2

GNSS RECEIVER T300

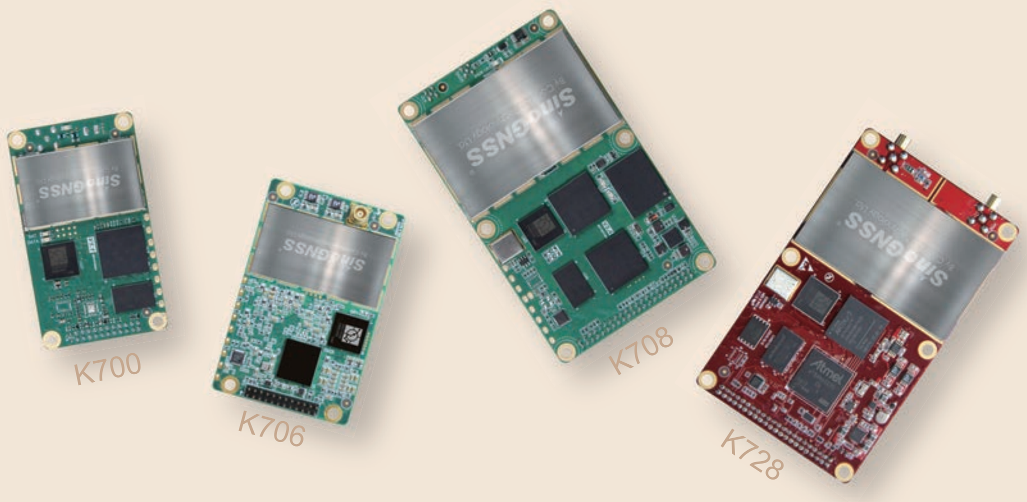


THE NEXT LEVEL RTK

GNSS RECEIVER M300 Pro



THE NEXT GENERATION CORS RECEIVER



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World Bank Land and Poverty Conference: Responsible Land Governance – Towards an Evidence-based Approach

The World Bank held the 18th Annual World Bank Conference on Land and Poverty from 20-24 March 2017 at its global headquarters in Washington DC, USA. The conference was attended by more than 1,250 participants from over 130 countries, including FIG President Chryssy Potsiou and Vice President Diane Dumashie. The majority of the participants were from developing countries, representing World Bank client governments, academia, NGOs and CSOs, the private sector and World Bank development partners.

Underpinned by recognising responsible land governance, the conference theme reflected the fact that large parts of some country populations may lack clear rights, documents may be out of date, and there are persistent failings in managing land to maximise social and economic benefits. Accordingly, the discussions and presentations considered how to close the gap between reality and legal provisions of land rights and management for urban and rural development. Three broad factors that could close this gap were identified, discussed and recorded in the conference forum and papers. These factors included: a) New data sources, including drones, and more comprehensive and regular coverage of land records with imagery that is often free or made available under new business models, b) better connectivity, and c) improvements in the ability to process data. FIG is a key partner of the Global Land Tool Network (GLTN) which played a very visible role during the week. FIG is involved in the development of operational standards for land administration, and a pre-conference event was dedicated to this subject.
The conference concluded with a clear message that building on the demonstrable capacity of the World Bank in analytics, together with its partners in all regions, can evidence and ultimately implement solutions. Notably, the ultimate partners are the politicians.

Dr Diane Dumashie, FIG vice president

More information
www.fig.net

Marine/Coastal SDI Best Practices and GSDI

Rapid changes in marine and coastal areas require implementation of processes and tools to enhance knowledge and management of these territories. Marine and Coastal Spatial Data Infrastructures (M/C SDIs) facilitate sharing and use of spatial data across a broad range of stakeholders by promoting data and metadata harmonisation and services interoperability. Efforts at national and international level are underway to increase efficiency in spatial data production and improve availability and accessibility to support the concepts of Integrated Coastal Zone Management (ICZM), Maritime Spatial Planning (MSP) and establishing effective Marine Cadastres.

In November 2015, GSDI launched the Marine/Coastal SDI Best Practice Project as one of its strategic projects through October 2017. The project was strengthened with additional funding from EuroSDR through 2018, with a strong focus on the 'land-sea interaction' aspect of marine/coastal data. The project is now embedded within the new GSDI Capacity Building Program 2017-2018, approved by the board in December 2016. Two marine/coastal best practice webinars were held in November 2016 and March 2017. The third is scheduled for June 2017, focusing on the land-sea interface, and the fourth for September 2017, focusing on marine cadastre.

The Marine/Coastal SDI Best Practice Project focuses on:

- frameworks for marine and coastal geographic data, services and infrastructures

- use of marine and coastal data and services across multiple sectors
- governance structures enabling effective use
- benchmark assessments of the data and services
- capacity-building challenges and solutions by adopting best practice.

The project is building a repository of M/C SDI good practices and was enhanced by the additional EuroSDR funding to extend project coverage to include:

- analysis of the roles of National Mapping and Cadastral Agencies (NMCAs) and Hydrographic Offices (HOs) in Europe in implementation of the EU Maritime Spatial Planning Directive (MSPD)
- identification of the contributions of National SDIs and Marine/Coastal SDIs in implementation of the EU Maritime Spatial Planning Directive.

GSDI is active on the International Hydrographic Organization (IHO) Marine SDI Working Group (MSDIWG) and on the Open Geospatial Consortium (OGC) Marine Domain Working Group (OGC MDWG). The IHO MSDIWG met in February in Vancouver, Canada, along with the OGC MDWG, which also met in Delft, The Netherlands, in May.

For more information, contact Roger Longhorn, GSDI secretary-general at secgen@gsdi.org.

More information
[1] gsdiassociation.org
[2] opendata.bk.tudelft.nl

IAG-IASPEI Scientific Assembly, Japan

The International Association of Geodesy (IAG) holds its Scientific Assemblies midterm between two IUGG-IAG General Assemblies. The next one will be held this year, midterm between the IUGG General Assemblies 2015 (Prague, Czech Republic) and 2019 (Montreal, Canada). It will be jointly organised with the International Association of Seismology and Physics of the Earth (IASPEI) in Kobe, Japan, from 30 July to 4 August. There will be nine joint IAG-IASPEI symposia and seven IAG-specific symposia.

JOINT SYMPOSIA

J01 Monitoring of the cryosphere
J02 Recent large and destructive earthquakes
J03 Deformation of the lithosphere: integrating seismology and geodesy through modelling
J04 Geohazard early warning systems
J05 Crustal dynamics: multidisciplinary approach to seismogenesis
J06 The spectrum of fault-zone deformation processes (from slow slip to earthquake)
J07 Tracking the sea floor in motion
J08 Imaging and interpreting lithospheric structures using seismic and geodetic approaches
J09 Geodesy and seismology: general contributions

IAG SYMPOSIA

G01 Reference frames
G02 Static gravity field
G03 Time variable gravity field
G04 Earth rotation and geodynamics
G05 Multi-signal positioning: theory and applications
G06 Geodetic remote sensing
G07 Global Geodetic Observing System (GGOS) and Earth monitoring services

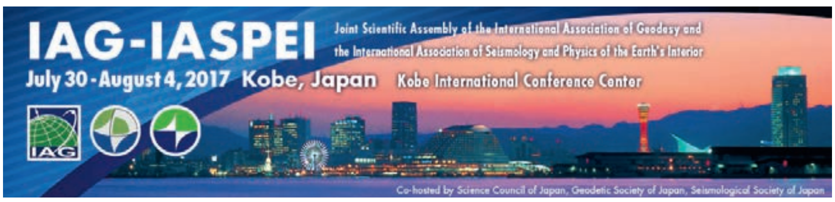
IMPORTANT DATES:

7 December 2016:	Registration open
10 May 2017:	Closure of early-bird registration
7 July 2017:	Pre-registration closes

For more details of the assembly please visit the website: http://www.iag-iaspei-2017.jp.

Hermann Drewes, IAG secretary-general

More information
http://iag-comm4.gge.unb.ca/



Advancing on Washington DC

Since the last two ICA columns for *GIM International*, which described the range of workshops organised by ICA Commissions prior to the main 28th International Cartographic Conference in Washington DC, one further meeting has been arranged. It is now included in the list of events at http://icaci.org/an-overview-over-the-icc2017-pre-conference-workshops.

This workshop, led by the active Maps & the Internet Commission, involves joint presentations with the Education & Training Commission and the Ubiquitous Mapping Commission. The workshop website at http://internet.icaci.org/commission-workshop-2017 indicates that the first day (30 June) will involve some hands-on coding of internet mapping exercises and functions, with a more formal day of presentations on 1 July covering a wide range of topics of common interest for these traditionally collaborative commissions. The venue is the attractive colonial town of Williamsburg, a few hours south of Washington DC.

As a pre-cursor to the main event, this workshop and the others reported in the past two editions of *GIM International* are ideal opportunities to whet the appetite for a feast of cartographic activity at the main Washington DC conference (2 July to 7 July). The conference website at www.icc2017.org gives details of how the week will unfold. Through its citizens, educational establishments, commercial and industrial companies, and governmental and non-governmental agencies, our host nation is extending the definition and applications of contemporary cartography; this is an ideal time to visit that nation's capital.

Several technical tours will visit governmental and private institutions to demonstrate such activity, whilst worldwide developments in all areas of cartography will be reported in the extensive scientific programme encompassing over 750 papers and posters. The social programme involves traditional American events, such as a Texas-style barbecue, and special excursions to the nation's past in a visit to all four of the meridians which were used historically as US prime meridians. The usual exhibitions will complement the scientific programme: the International Cartographic Exhibition showcases the highlights of activity in ICA member nations, the Children's Map Competition promotes creative representations of the world in graphic form by children from around the world, and the International Trade Exhibition offers the chance for over 2,000 delegates to connect with world-leading commercial, governmental and academic organisations and NGOs.

Washington DC is traditionally hot in July, and attendance at this event is a 'hot ticket' to witness and influence developments in our discipline.

More information
www.icaci.org

ISPRS on LinkedIn and Facebook

The International Society for Photogrammetry and Remote Sensing (ISPRS) is a non-governmental organisation devoted to the development of international cooperation for the advancement of photogrammetry and remote sensing and their applications. ISPRS is a society which connects the national societies in this field on an international level. To provide platforms where not only members of the national societies but also all individuals interested in the field of photogrammetry, remote sensing and geoinformation at international level can discuss related topics and exchange information, ISPRS has established interest groups on the LinkedIn professional network and Facebook. One special interest group of ISPRS on Facebook, namely the ISPRS Student Consortium, currently has more than 5,000 members. We invite you to join the ISPRS interest groups on social media and are looking forward for your contributions.

Uwe Stilla President of the German Society for Photogrammetry, Remote Sensing and Geoinformation

More information
www.isprs.org

2017

MAY

XPONENTIAL 2017
Dallas, USA
from 8-11 May
For more information:
www.xponential.org/xponential2017

GEO BUSINESS 2017
London, UK
from 23-24 May
For more information:
http://geobusinessshow.com

FIG WORKING WEEK 2017
Helsinki, Finland
from 29 May - 2 June
For more information:
www.fig.net/fig2017

JUNE

HEXAGON LIVE
Las Vegas, USA
from 13-16 June
For more information:
hxgnlive.com/2017

JULY

INTERNATIONAL CARTOGRAPHIC CONFERENCE
Washington, USA
from 2-7 July
For more information:
icc2017.org

ESRI USER CONFERENCE
San Diego, USA
from 10-14 July
For more information:
www.esri.com/events/user-conference

SEPTEMBER

UAV-G 2017
Bonn, Germany
from 4-7 September
For more information:
uavg17.ipb.uni-bonn.de

ISPRS GEOSPATIAL WEEK
Wuhan, China
from 18-22 September
For more information:
zhuanti.3snews.net/2016/ISPRS

INTERGEO
Berlin, Germany
from 26-28 September
for more information:
www.intergeo.de

OCTOBER

COMMERCIAL UAV EXPO AMERICAS
Las Vegas, USA
from 24-26 October
For more information:
www.expouav.com

COMMERCIAL UAV EXPO EUROPE
Brussels, Belgium
from 31 October - 2 November
For more information:
www.expouav.com/europe

CALENDAR NOTICES

Please send notices at least 3 months before the event date to: Trea Fledderus, marketing assistant, email: trea.fledderus@geomares.nl

For extended information on the shows mentioned on this page, see our website: www.gim-international.com.

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